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Adar yng Nghymru

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Edited by Rhion Pritchard

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Editorial

This year we have the results of two surveys conducted in Wales in 2014 to assess the fortunes of two of our most charismatic birds. Graham Williams discusses the findings of the Peregrine survey and Daniel Hayhow et al. the findings of the Chough survey. Both show a mixed picture, with declines in some areas, though the probable reasons for this are not the same in both species. I hope that the results of every national bird survey carried out in Wales can be reported in Birds in Wales, as it is a good way of giving feedback to volunteers who participated in the survey, and also of great interest to everyone concerned with Wales' birds.

Improvements in GPS technology are now making tracking the movements of even comparatively small birds possible, and the results are often fascinating. The study of the feeding movements of Manx Shearwaters from the Bardsey colony, by Ben Porter and Stephen Stansfield, was given financial assistance by the Welsh Ornithological Society. The results show that these birds travel considerable distances to feed, with interesting individual variations in strategy. We have two papers on the Greenland White-fronted Goose, a subspecies which can still legally be shot in Wales despite a worrying decrease in its numbers in recent years. The first, by Carl Mitchell et al., also uses GPS technology, this time to track the movements of birds wintering on the Dyfi estuary and follows their journeys to their breeding sites in west Greenland. The second paper, by Mick Green and Carl Mitchell, looks at the distribution of records of this race in Wales since 2000, and considers the implications for their conservation. Finally, we have a short paper by David Smith reporting on a survey of the Ring Ouzel population of the Aran mountains in Meirionnydd, an area where there have been few if any ornithological surveys prior to this one.

Thanks to Tony Fox, Bob and Annie Haycock, Geoff Gibbs and Ivor Rees for acting as referees. I thank Ian Spence for his help with the layout of this and previous issues of our journal. Thanks to Kelvin Jones for taking responsibility for the photographs, and to the photographers, credited individually for each photograph, for permission to use their work.

It is now time to consider papers for next year's Birds in Wales. If you have any ideas for papers dealing with any aspect of ornithology in Wales, please get in touch with me to discuss them.

Rhion Pritchard

The Breeding Population of the Peregrine (*Falco peregrinus*) in Wales in 2014

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Crynodeb

Mewn arolwg o'r Hebog Tramor yng Nghymru yn ystod haf 2014, cafwyd hyd i/amcangyfrifwyd 279 o diriogaethau mewn defnydd. Roedd hyn yn ostyngiad o 13% o'i gymharu â'r un arolwg yn 2002, ac felly'n dynodi newid cyfeiriad yn dilyn y cynnydd digyffelyb a welwyd ers y 1980au. Gwelwyd y lleihad mwyaf ar ucheldir Gogledd a Chanolbarth Cymru, tra i'r gwrthwyneb bu cynnydd bychan ym Morgannwg a Mynwy. Cyflwynir y canlyniadau fesul is-sir.

Summary

A survey of Peregrines in Wales during the summer of 2014 located/estimated 279 occupied nesting ranges. Overall this was a 13% decrease from the identical survey in 2002 and, as such, marks a change of direction from the unprecedented increase which had taken place since the 1980s. The decline was most marked in upland areas of North and Central Wales, partly offset by continued small increases in Glamorgan and Monmouth. Results are presented by vice-county.

Introduction

National surveys of the UK breeding Peregrine population have been undertaken every ten years since 1961/1962 under the aegis of the British Trust for Ornithology. In 2014, as in 1991 and 2002, the Wales Raptor Study Group arranged coverage within Wales. Coverage in Wales in 2014 was not as comprehensive as in 2002 which led to it being necessary to include estimates for a number of unchecked nesting ranges in some vice-county totals.

Materials and methods

In accord with previous censuses the data which are summarised in the present paper are site-based and therefore have the advantage of being directly comparable with results for earlier surveys. It should also be noted that to have the benefit of direct comparison with the results for Wales in 2002 (Thorpe and Young 2004) sites are included where it appeared that only a single bird was in occupation.

Results in this paper are therefore in contrast with the figures for Wales presented in the national BTO survey (Wilson et al. 2018) where, for the first time in the decadal survey, an area-based random square estimate was introduced. This was done in order to enable an estimate of the number of pairs occupying newly colonised areas not occupied during the previous survey, which was particularly relevant for parts of England. A further difference is that the BTO analyses assume that 50% of single birds are part of a pair as recommended by Ratcliffe (1993) and following the approach taken by previous national surveys of this species (e.g. Banks et al. 2010).

Site surveys were carried out between the beginning of March and mid-July in accordance with established raptor monitoring protocols (Hardey et al. 2009). Mark Wilson, the BTO's lead organiser, provided the author with details of Welsh records submitted to the 2014 National Survey. Scrutiny of these revealed that there were some substantial gaps in coverage; many of these have been filled for this paper through data that had not been provided to the 2014 National Survey. Although this considerably improved the situation it was still clear that coverage in some vice-counties was incomplete. In these cases a correction has therefore been applied, by taking the rate of occupancy to be the same for checked and unchecked sites.

Results

The results show the number of breeding ranges occupied by a pair or single adult for each vice-county, with a distinction between coastal (C) and inland (I) sites.

	1930-39		1981		1991		2002		2014	
	C	I	C	I	C	I	C	I	C	I
ANGLESEY	5	0	3	0	9	2	11	3	8	0
BRECON	0	6	0	4	0	16	0	21	0	19
CAERNARFON	11	14	5	20	13	28	10	26	12	20
CARMARTHEN	2	2	1	1	3	12	3	14	3	11
CEREDIGION	8	4	6	5	11	13	15	17	14	9
DENBIGH	0	3	0	5	0	21	0	19	0	16
FLINT	0	0	0	0	0	2	1	5	1	3
GLAMORGAN	6	4	2	6	5	16	9	33	8	39
MEIRIONNYDD	0	17	0	20	0	46	0	40	0	28
MONMOUTH	0	3	0	2	1	7	0	11	0	17
MONTGOMERY	0	7	0	6	0	23	0	22	0	15
PEMBROKE	30	1	19	0	36	3	40	6	39	3
RADNOR	0	5	0	3	0	13	0	15	0	14
Total	**62**	**66**	**36**	**72**	**78**	**202**	**89**	**232**	**85**	**194**

The results detailed above show that the coastal population in Wales remained relatively stable between 1991 and 2014. In contrast the inland population in a core upland area from Caernarfon through Denbigh, Meirionnydd, Montgomery and Ceredigion has declined markedly over the same period; in Anglesey the small inland population has collapsed whilst it has declined slightly in Pembroke. More urbanised areas of South Wales have, however, fared much better and the Peregrine population of Glamorgan and Monmouth has continued to increase.

Figure 1. Derek Ratcliffe (1929-2005), the doyen of all Peregrine fieldworkers, at an eyrie in North Wales, April 28th, 1978.

Discussion

The recent decline in the Welsh inland population was noted by Thorpe and Young (2004) and Banks et al. (2010). The most plausible cause of this decline is likely to be a recent reduction in the available prey base.

One compelling insight into this decline is provided by the work of the South Wales Peregrine Monitoring Group in the Central Wales part of their monitoring area (encompassing Brecon and inland parts of Carmarthen and Ceredigion); this study associated a declining population of Peregrines with a reduction in racing pigeon availability (Dixon et al. 2010). In that area an average of 13 breeding pairs of Peregrines in 1993 – 2004 declined to just seven in 2009 and it was shown that breeding failed at nearly a quarter of all occupied territories in the period 2005 to 2009. It has been identified that racing pigeons were an important prey, especially for inland Peregrines (Dixon and Richards, 2003). In the Central Wales study, on average 34% of racing pigeons killed came from South Wales lofts but the numbers declined substantially over the period as a result of a change of strategy by pigeon fanciers. From the 1990s many pigeon fanciers in South Wales had begun to change their traditional racing routes from northerly liberation points to southerly ones with the result that far fewer racing pigeons from lofts in South Wales were passing through Central Wales. Since racing pigeons were a significant component (31%) of the Peregrine's diet during the pigeon racing season (April to September inclusive) this change has inevitably had an impact on Peregrine prey availability during the breeding season.

It is noteworthy that the switch in race routes will not have resulted in a reduction in the availability

of racing pigeons for Peregrines nesting in South Wales where, as has been shown, the population in Glamorgan and Monmouth has continued to increase. That part of Wales does have a relative abundance of racing pigeons and town-dwelling feral pigeons coupled with the benefit of a substantial number of disused and working quarries providing plentiful nesting sites.

A further factor in the availability of prey, which applies to all inland parts of Wales, is the general impoverishment of upland and moorland breeding bird communities (e.g. Lovegrove et al. 1995; Crump and Green 2012; Roberts 2014; Smith 2014). This is particularly relevant where the species concerned are of sufficient bulk to provide sustenance for the needs of a nesting pair with young. In some areas the demise of upland breeding colonies of Black-headed Gulls (*Larus ridibundus*) and of lowland colonies of Rooks (*Corvus frugilegus*) which regularly foraged in nearby improved upland pasture may be of special note in this regard.

Adverse impact on breeding Peregrines in Wales, as elsewhere, has also been generated by long-standing hostility to the species from a variety of sources. RSPB data (Guy Shorrock, pers. comm.) showed that from 2000 to date there were 21 confirmed poisoning incidents in Wales involving Peregrines or where pigeon baits were intentionally placed for Peregrines; 9 cases of shooting, trapping or nest destruction and 12 confirmed incidents of the taking of Peregrine eggs or chicks. These confirmed incidents, which probably represent a small fraction of the total crimes, occurred in all parts of Wales but especially in Glamorgan/Monmouth and in Anglesey/Caernarfon and may have been the cause of the demise of a number of marginal breeding ranges.

Availability of nesting sites is clearly not a limiting factor in much of Wales, as evidenced by the large number of traditional nesting ranges which are now deserted. Even in the areas with a burgeoning population it appears that the number of quarries, even those still being worked, coupled with

Figure 2. Four dead Peregrines at a nest in the Nantlle Valley, Caernarfon, June 2014. It was not possible to recover the bodies for tests, but poisoning is suspected.

natural crags, can accommodate the increase to date without the widespread use of various man-made structures (as has occurred in the phenomenal recent increase in England). Nevertheless, some artificial structures were used in 2014: a steel ledge on the Britannia Bridge between Anglesey and Caernarfon (first used by breeding Peregrines as long ago as 1945 – 46); two urban sites in Wrexham and Flintshire; a disused rail track loading arm in Pembrokeshire; a factory roof in Monmouth; and Cardiff City Hall plus two further locations in Glamorgan (one of which was an electricity pylon).

Acknowledgements

The author is particularly grateful for the detailed information and help from Colin Richards and Andrew King on the Peregrine situation in the area covered by the South Wales Peregrine Monitoring Group, which was crucial in producing this paper. Other assistance was provided by Peter Jennings (a summary of the Radnor population) and in helpful discussions with Reg Thorpe, Kelvin Jones, Keith Offord, John Lawton Roberts, Ian Spence, Tony Cross and Jerry Lewis.

Mark Wilson supplied the Welsh data that had been submitted to the U.K. survey; he also made constructive comments on the draft of this paper, as also did Andrew King.

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Appendix

The following allowances were made for unchecked nesting ranges:
Caernarfon: inland, one. Carmarthen: inland, four. Ceredigion: coastal, two; inland, four. Flint: inland, one. Meirionnydd: inland, eight. Monmouth: inland, three.

The breeding status of Red-billed Choughs (*Pyrrhocorax pyrrhocorax*) in Wales in 2014

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Crynodeb

Cymru yw cadarnle poblogaeth y Fran Goesgoch yn y D.U. ac Ynys Manaw. Gan ddefnyddio data o'r arolwg diweddaraf o'r boblogaeth yn 2014, ynghyd â data o'r monitro blynyddol, rydym yn disgrifio statws y Fran Goesgoch yng Nghymru ac yn asesu newidiadau mewn niferoedd yn genedlaethol ac yn rhanbarthol ers yr arolygon blaenorol yn 1992 a 2002. Cafwyd hyd i gyfanswm o 236 pâr yng Nghymru yn 2014. Dros Gymru, mae poblogaeth y Fran Goesgoch wedi cynyddu'n sylweddol ers 1992 (44%, 150-177 pâr), gyda chynnydd bychan ers 2002 (2%, 208-228 pâr). Fodd bynnag, mae amrywiaeth mewn tueddiadau rhanbarthol, gyda lleihad mewn rhai ardaloedd a phryder arbennig am y niferoedd o'r Fran Goesgoch sy'n nythu ymhell o'r môr yng ngogledd a chanolbarth Cymru.

Summary

Wales is the stronghold of the UK and Isle of Man Chough population. Using survey data from the most recent survey of the population, carried out in 2014, alongside annual monitoring data we describe the state of Chough in Wales and assess change in numbers nationally and regionally since previous surveys in 1992 and 2002. A total of 236 pairs were located in Wales in 2014. Overall the Chough population has increased substantially since 1992 (44%, 150-177 pairs) with only a slight increase since 2002 (2%, 208-228 pairs). However, there is variation in regional trends with declines in some areas and particular concern about numbers of Chough breeding inland in north and mid-Wales.

Introduction

Red-billed Choughs (hereafter referred to as Choughs) are found in a number of small discrete populations in Brittany, Ireland, the UK, and the Isle of Man. These populations are recognised as the north-west Europe race *Pyrrhocorax p. pyrrhocorax*, and considered to be distinct from those in southern Europe *Pyrrhocorax. p. erythrorhamphos* (Monaghan 1988 but see Wenzel et al. 2012). In the UK and Isle of Man Choughs were quite widespread prior to declines throughout the 19th century (Bullock et al. 1983). Signs of recovery were evident in the early 20th century on the Isle of Man and in Wales but declines continued in England and Scotland.

Wales has long been a stronghold for Chough. In the 2002 survey of Chough in the UK and Isle of Man, Wales was reported to hold 53% of the population. The importance of this species is recognised by its inclusion on the list of species of 'key significance to sustain and improve biodiversity in relation to Wales' published by the Welsh Government (under section 7 of the Environment Act (2016)). At a UK level the species was included on the Green list of Birds of

Conservation Concern, due in part to a change in this latest assessment of the treatment of conservation concern at the European level (Eaton et al. 2015). Currently, the species is Amber listed in the equivalent Welsh assessment (Johnstone and Bladwell 2016) and a more recent assessment of extinction risk for birds in Great Britain using IUCN criteria classified Chough as Vulnerable due to a small, restricted breeding population (Stanbury et al. 2017).

As in other parts of the UK and Isle of Man, Choughs in Wales have a predominantly coastal distribution, found in open habitats shaped by low-intensity pastoral agriculture. Inland breeding populations occur elsewhere in their European range (Hagemeijer and Blair 1997) and in north Wales a small inland population exists around Snowdonia in the vice-counties of Caernarfonshire, Meirionnydd and Ceredigion. There are seven Special Protection Areas (SPAs) classified for Choughs in Wales, six coastal and one inland, covering over 7,500ha. Choughs are listed as a qualifying breeding feature for all seven Welsh SPAs, and as a qualifying wintering feature for six coastal SPAs (Stroud et al. 2001). However, robust evidence from annual ringing, resighting and monitoring indicate that in north Wales there is substantial connectivity between coastal breeding populations and inland foraging locations during the non-breeding season. In particular, upland pastures are important to flocks of pre-breeding birds (Cross and Stratford 2015). This indicates that SPA coverage does not encompass all important sites and habitats for Chough and may be insufficient to meet the species' ecological requirements in the non-breeding season.

As the species is highly associated with short-grazed pastures or impoverished soils, it is susceptible to changes in land use and agricultural practices (Whitehead et al. 2005). The abundance, body size and accessibility of Chough prey can be impacted by such changes. In Wales Chough prey include ants, leatherjackets (cranefly larvae) and beetle adults and larvae especially chafers (McCraken and Bignal 1998).

The results of the three previous census surveys of the UK and Isle of Man Chough population in 1982 (Bullock et al. 1983), 1992 (Green and Williams 1992, Berrow et al. 1993, Sapsford and Moore 1994) and 2002 (Johnstone et al. 2007) are summarised in Johnstone et al. (2007). The results for Wales specifically can be found in Thorpe and Johnstone (2002). The increasing population trend between 1992 and 2002 across the UK and Isle of Man (35%) and in Wales (44%) contrasts with declines found in Scotland. Within Wales there were declines in northern and midland counties over the same period (Johnstone et al. 2007).

Since the 2002 survey annual monitoring in north Wales has shown a 22% decline (2002-2012) in numbers of Chough nesting inland in Meirionnydd and Caernarfon. In mid-Wales inland sites have been abandoned over a similar period; where ten sites were occupied in the early 1990s only one site remained occupied in 2012 (Cross and Stratford, unpublished data). Research to identify drivers of regional declines indicate that short swards, which allow easy access to soil and dung invertebrate prey, have been lost through both policy driven agricultural intensification (ploughing, reseeding and increased fertiliser use) and conversely the abandonment of grazing (Bullock et al. 1983, McCracken and Bignal 1998, Johnstone et al. 2002, Cross and Stratford 2015).

A comprehensive assessment of changes in Chough breeding abundance and range change in the UK and Isle of Man since 2002 will be published in Hayhow et al. (in press). Here we present the results from Wales and use ongoing annual monitoring to add context to the discussion and interpretation of these trends.

Methods

Sites for survey were identified by collating details of Chough breeding locations (nest sites or 1km squares used at some time since 1982) using data from three principal sources: the 2002 UK and Isle of Man Chough survey (Johnstone et al. 2007), the Rare Breeding Birds Panel, and Bird Atlas 2007-11 (Balmer et al. 2013). Most areas are monitored annually, so liaison with Chough Study Groups and volunteers was an essential part of planning for the survey to ensure no sites were missed. Information from local annual monitoring was also used as a guide to identify expected areas of stability, decline or expansion. In areas with reported increases (e.g. Glamorgan), surveys encompassed areas of apparently suitable habitat as well as locations with a history of occupancy. The survey in Wales followed the standard survey method, which involved two survey visits to each site, the first between 6 April and 6 May, and the second between 7 May and 15 June 2014 (as per Bullock et al. 1983). These methods remained unchanged from the 2002 Statutory Conservation Agencies & RSPB Annual Breeding Bird Surveys (SCARABBS) survey (Johnstone et al. 2007) with the exception of increasing the time watching known nests from 60 to 90 minutes, unless evidence of breeding status was obtained in a shorter period. This increase in watch time was recommended, based on information from Chough study groups, to confirm absence with greater certainty and confidence.

Survey work was carried out by two professional full-time fieldworkers in north and mid-Wales, and in south-Wales coverage was achieved by staff and volunteers from the Pembrokeshire Coast National Park Authority, National Trust, Wildlife Trust South and West Wales, Natural Resources Wales and Ministry of Defence and the RSPB.

Chough breeding status was classified as confirmed, probable or possible using a well-established classification scheme of characteristic behaviours (as detailed in Johnstone et al. (2007)). Additional site details were recorded including nest type, natural or artificial (quarries, mineshafts and built structures or specifically designed nest ledges and boxes) and coastal or inland location. Inland sites were defined as those >1 km from the Mean High Water Mark (Berrow et al. 1993, Sapsford and Moore 1994). Additional data were collected (not as part of the census) from colour-ringing and nest visits to measure breeding success. Colour-ring re-sightings enabled wide-ranging pairs to be eliminated from suitable sites that they visited but where they did not breed, these findings were used to inform results.

National population estimates were based on all available information (e.g. standard two visit survey counts as well as additional visits, colour-ring studies, visits to nests for ringing). Counts from the standard two visits method were compared with this and the discrepancy between estimates are reported. Population changes between the surveys (1992, 2002 and 2014) were calculated using data from the standard two visits, to reduce the impact of varying survey intensity between years.

To get the best estimate of the numbers of non-breeding Chough in 2014, the following approach was concluded by Johnstone et al. (2007) to be the most feasible and consistent method to reduce incidents of double-counting. Counts of non-breeding birds during first visits (6 April to 6 May) were summed if (a) they were observed on the same day, or (b) they were >5km apart when observed on different days. There are exceptions where the same colour-ringed individuals were common to two flocks >5km apart in which case the flock was assumed to be mostly the same group and only counted once.

Results

Survey coverage in Wales was extensive; a total of 320 1km squares with 515 previous Chough breeding locations were identified (Table 1). In addition to known breeding locations, in south Wales (Pembrokeshire and Glamorgan), approximately 100km of apparently suitable coastline was also surveyed. The majority of sites (68%) received at least 2 survey visits. The remaining sites received single visits, the majority of these were located in north and mid-Wales, and in many cases a second visit was not necessary as site occupancy was confirmed from a single visit. A small number of sites were not revisited as they were considered to have a low likelihood of occupancy. Confidence in this assessment comes from twenty years of annual monitoring and colour-ringing and re-sighting in this area providing detailed history of occupancy of most sites, as well as information about alternate nest locations within the home range of an already occupied nest. Colour-ringing in particular has also improved knowledge of territory usage by individuals and this information was used to determine whether there were unaccounted for pairs in the area (A. Stratford pers comm.; Cross & Stratford Welsh Chough Project).

	Number of		Survey Coverage (number of sites (%))					
County	Known breeding locations	1-km squares	visited twice	(%)	visited at least twice	(%)	visited less than twice	(%)
Anglesey	76	41	19	(25)	54	(71)	22	(29)
Caernarfon	168	86	25	(15)	98	(58)	70	(42)
Denbighshire	5	4	0	(0)	4	(80)	1	(20)
Meirionnydd	42	22	8	(19)	23	(55)	19	(45)
Montgomery	9	8	2	(22)	2	(22)	7	(78)
Ceredigion	54	36	8	(15)	23	(43)	31	(57)
Pembrokeshire	144	109	112	(78)	138	(96)	6	(4)
Glamorgan	17	14	4	(24)	6	(35)	11	(65)
Wales total	515	320	178	(35)	348	(68)	167	(32)

Table 1. Distribution of Chough breeding locations surveyed across Wales and survey coverage achieved in each region.

Survey visits in Wales, as in other parts of the UK and Isle of Man, were carried out in between the required dates (6 April - 6 May and 7 May - 15 June) for 99% of first visits and 92% of second visits.

Breeding population size and range

The census in Wales in 2014 found 236 confirmed and probable breeding pairs, with the estimate increasing to 261 pairs if possible breeding records are included. As shown in Table 2 this estimate, based on all available data (e.g. additional visits) is 11% higher than the estimate (213 pairs) using data from standard two visits alone.

The largest population across the UK and Isle of Man was found in Wales (55%) followed by the Isle of Man (31%). Pembrokeshire and Caernarfon held 13% and 20% of the UK and Isle of Man population respectively.

		Evidence of breeding based on two standard visits			Totals based on two standard visits		Totals based on all information		Discrepancy (%)		% UK & Isle of Man population	Non-breeding population	
Country	County	Poss	Prob	Conf	Conf & Prob	Conf & Prob & Poss	Conf & Prob	Conf & Prob & Poss	Conf & Prob	Conf & Prob & Poss		No.	%*
Wales	Anglesey	5	2	33	35	40	40	41	14	3	9	16	16
	Caernarfon	14	4	74	78	92	87	90	12	-2	20	64	26
	Denbighshire	0	0	2	2	2	2	2	0	0	0	1	20
	Meirionnydd	1	1	16	17	18	18	18	6	0	4	39	52
	Montgomery	0	0	0	0	0	0	0			0	0	
	Ceredigion	6	0	21	21	27	27	29	29	7	6	15	21
	Pembroke-shire	15	7	49	56	71	58	73	3	3	13	64	30
	Glamorgan	4	0	4	4	8	4	8	0	0	1	7	30
Wales total		**45**	**14**	**199**	**213**	**258**	**236**	**261**	**11**	**1**	**55**	**206**	**28**

Table 2. Chough national and regional population estimates for Wales. Estimates shown are calculated from two standard visits and using all additional information. The discrepancy (%) between these estimates is included to show the influence of additional information on estimates (>2 standard surveys and colour ring records). The percentage of the UK and Isle of Man population in each area (based on confirmed and probable totals using all additional information) and the non-breeding population estimates are also shown.

* Based on counts of non-breeding birds and the sum of possible, probable and confirmed breeding pairs (multiplied by two to represent individuals)

Occupied sites were recorded in 59 10km squares across Wales (Figure 1). At a finer scale, 201 1km squares were occupied, of which 80% contained a single nest site (based on possible, probable or confirmed breeding records).

Figure 1. Distribution of Chough breeding pairs in Wales in 2014. Grey squares show areas of continued occupancy in 2002 and 2014. Range loss and expansion indicated by triangles. Triangles that overlay squares show net increase (green) and decrease (orange) in number of pairs within squares (light green/orange = 1-2pairs, mid green/orange = 3-5 pairs, dark green = 6-8 pairs).

In Wales, 85% (n=223) of nest locations were coastal with the remainder (n=38) being inland. Inland sites were mostly in the counties of Meirionnydd (n=9) and Caernarfonshire (n=25). Inland nesting does occur in Scotland and the Isle of Man but the distance from inland nest sites to the coast in Wales is much greater (c.20km). There were no known instances of Choughs nesting inland in England or Northern Ireland in 2014 (Hayhow et al. in press). The majority (73%, n= 191) of occupied nests in Wales were natural, with the remaining 27% being artificial (n=70). Artificial nests on the coast (n=38) included boxes and reinforced nest ledges/platforms. These have been put in place in cases where the natural cliff at a traditional nest site had fallen away, or, in the case of the Ceredigion coast, where natural sites on the shale cliffs were poor quality, scarce or of short duration. Inland, 31 artificial nests were found in mineshafts and quarries and 6 natural nests were located in crevices or holes in rock outcrops. This contrasts with Scotland where inland nest sites were predominantly found in buildings (Hayhow et al. in press).

Comparison with population sizes from previous surveys

We have calculated population change using confirmed and probable totals derived from the standard two survey visits. The Chough breeding population in Wales has increased by 42% since 1992, from 150 (Green and Williams 1992) to 213 pairs. In more recent years, numbers show little change, up by 2% from 208 pairs in 2002. However, trends have varied regionally. Between 2002 and 2014 numbers declined in Ceredigion, Anglesey and Caernarfon. No Chough were found to be breeding in Montgomery in 2014. By contrast, in Glamorgan 4 confirmed pairs were reported in 2014, compared to a single probable pair in 2002. The number of Chough nesting in Pembrokeshire has increased; 56 pairs were located in 2014 compared to 46 in 2002 (22% increase).

Across the UK and Isle of Man there was minimal change in the number of pairs of Chough on the coast and inland since 2002 (Hayhow et al. in press). In Wales there was a clearer pattern, numbers of Chough on the coast have increased by 9% compared to a 17% decline inland (Table 3).

Numbers of non-breeding Choughs

The number of non-breeding Chough, predominantly pre-breeding birds (<2-3 years old), in 2014 was 206, representing 28% of the Welsh population. Non-breeding birds made up 52% of the population in Meirionnydd (this included birds from surrounding counties drawn into a significant non-breeding flock and roost) and 30% in Pembrokeshire and Glamorgan. The overall proportion of non-breeding birds in Wales showed a slight increase from 21% in 2002.

Discussion

The field methods and the subsequent interpretation of behaviours used in the 2014 census followed recommendations from the previous survey (Johnstone et al. 2007). In 2014 additional information, over and above that obtained from the standard two-visit survey method, increased the number of confirmed and probable breeding pairs identified in Wales by 11%. As well as identifying pairs that may have been missed during the standard two visits, the clear benefit arising from additional survey effort is the confirmation of breeding status which may have been wrongly classified. This was the case in Ceredigion, where the discrepancy between standard visit results and those based on all additional information was as high as 29%. We feel that for the purposes of a national survey (UK and Isle of Man), the standard two survey visits should still be considered to provide an adequate estimate of population size and a standardised method to calculate trends.

	2002*		2014		% change	
Counties	**Coast (%)**	**Inland (%)**	**Coast (%)**	**Inland (%)**	**Coast**	**Inland**
Anglesey	38 (97)	1 (3)	40 (98)	1 (2)	5	0
Caernarfonshire (incl Bardsey)	64 (69)	29 (31)	65 (72)	25 (28)	2	-14
Ceredigion	27 (96)	1 (4)	28 (97)	1 (3)	4	0
Denbighshire	1 (50)	1 (50)	0	2 (100)	-100	100
Meirionnydd	4 (24)	13 (76)	9 (50)	9 (50)	125	-31
Montgomeryshire	0	1 (100)	0	0	0	-100
Pembrokeshire	67 (100)	0	73(100)	0	9	0
Glamorgan	4 (100)	0	8 (100)	0	100	0
Wales Total	**205 (82)**	**46 (18)**	**223 (85)**	**38 (15)**	**9**	**-17**

Table 3. Nest location in Wales occupied by confirmed, probable and possible pairs and % change between 2002 and 2014 by county (inclusion of possible pairs in this table mean that totals differ from those in Table 2).

*2002 figures for nest location vary slightly from Johnstone et al. (2007) due to improved knowledge of specific nest sites and differences in GIS methods used to identify coastal and inland sites.

Context provided by ongoing annual monitoring

Annual monitoring and colour-ringing in north and mid-Wales has substantially improved our understanding of Chough population dynamics and distribution and increased knowledge of nesting and foraging locations (Cross and Stratford 2015). In the late 2000s, increasing coverage identified 22 nest sites, which, while not previously located were considered by surveyors to have been occupied for some years prior to discovery, based on the presence of a build-up of old nest material. It is possible, therefore that these sites were in fact occupied during previous surveys and up to 14 additional pairs may have been undiscovered in 2002 (if the rate of occupancy of these 22 sites was similar to the proportion of occupied sites across the region) (Cross and Stratford unpublished data). The implication of this is that the 5% decline in north and mid-Wales between 2002 and 2014 reported here could be an underestimate. If these 14 pairs are added to the published figure for 2002 and compared against results from 2014 this gives an 11% decline in north and mid-Wales. In turn, this would mean that the trend for the whole of Wales would be slightly negative (-4%).

At the scale of the UK and Isle of Man Chough population, efforts to standardise monitoring of Chough in future by annual surveys of a representative sample of survey units (e.g. 1km squares or defined territories / breeding locations), would ensure a proportionate level of coverage is maintained across regions. This would improve our ability to detect change in numbers and provide the data required for analyses to determine national and regional drivers of change. There would remain a number of challenges to consider and any sampling approach would need to be stratified to consider a number of factors. Firstly, the variation in nest density per 1km square and the need to be able to detect changes in nest density within the existing range. Secondly, the need to include areas with suitable habitat but no previous history of occupation in order to detect population expansion. Finally, Chough territories may span 1km squares with alternate nest sites falling into different squares in which case another survey unit may be more appropriate. For remote inland mountainous areas with low breeding density a sampling approach may not always be appropriate.

Possible causes of population change

It is clear from the varying population trends across Wales that different factors are likely to be impacting the population in different areas. While it is beyond the scope of this paper to define the specific drivers of change in the Welsh Chough population, we discuss briefly some of the likely factors involved.

There are two large-scale factors that need to be considered; climate change (current and projected) and genetic diversity of Chough populations. Firstly, given current evidence of climate change in the UK to date, it is not implausible that conditions in the southern parts of the range (Glamorgan and Pembrokeshire) may have been more beneficial for Chough in recent years which could have contributed to population increases through enhanced breeding success and survival. Longer term however, climate projections for the UK are for wetter winters, drier summers and an increasing frequency and intensity of extreme weather events (in particular a larger proportion of annual rainfall is projected to fall in the form of heavy rainfall events) (Humphrey and Murphy 2017), all of which could have a negative impact on Chough by reducing invertebrate activity and abundance (Reid et al. 2003, Reid et al. 2011).

Secondly, there is low genetic diversity in Chough populations in north-west Europe, and a north-south gradient in diversity has been reported with Brittany having the highest and Scotland and Isle of Man having the lowest diversity (Wenzel et al. 2012). While low levels of gene flow do occur naturally, for example, dispersal and subsequent breeding has been recorded between north Wales and the Isle of Man (Moore 2006, 2008), questions about the viability of small discrete Chough populations have been raised.

Specific factors involved in the population increase reported here (mainly in south Wales) remain unclear and would require further research. The impact of large-scale habitat restoration schemes between multiple partners in Pembrokeshire may have been beneficial in improving and increasing the habitat available for Chough but the impact of this and other measures including agri-environment prescriptions on population growth has yet to be quantified.

Conversely, changes to land use and agricultural practices have negatively impacted the amount of suitable foraging habitat and the availability and abundance of Chough prey. Coastal and inland grazed areas with short swards of semi-natural vegetation have become less suitable or lost, both through intensification and conversely abandonment of grazing (e.g. in some cases through pressure for re-wilding remote areas). Land with intensely managed sward has been shown to support invertebrates with smaller body sizes, which reduces the profitability of prey despite providing appropriate sward height (McCracken and Bignal 1998).

The divergence of trends highlighted here for Chough breeding inland and on the coast is of particular concern. In north and mid-Wales, where the majority of inland breeding Choughs are found, the reduction in upland grazing (14% decline in sheep numbers in Snowdonia between 2002 and 2010 (Silcock et al. 2012)) has resulted in loss of the short sward pastures Chough require. This policy driven decline in grazing is compounded by limited options under the current agri-environment scheme to manage unenclosed habitat in alternative ways. Current options are associated with heather moorland restoration and therefore only limited grazing is allowed (Welsh Government 2017).

While there have been some occurrences of inland sites having been lost in the past (by being grilled over or infilled for public safety or for protection of bats, fly-tipping resulting in rat predation of

nests, scrubbing over of old mine shafts, modern slate extraction methods resulting in loss of old cavern sites, as well as quarry activities within working quarries) these are not considered to be a significant factor in recent declines, where many suitable inland nest sites now remain vacant. However, given loss of suitable foraging habitat inland, these are unlikely to be re-occupied without landscape-scale change in habitat management.

Concluding remarks

Low-intensity pastoral farming provides the essential habitat for Choughs. This brings opportunities for Chough conservation in combination with protection of landscapes of high cultural value. Some perceived conflicts remain – for instance where the requirements of food production, or of different species groups are seen to be in competition with each other. It is possible however to integrate the requirements for a range of species groups by putting in place appropriate grazing management to maintain areas of low-intensity pasture for botanical and invertebrate interests in such a way that is very much compatible with the needs of species such as Chough, Wheatear and Ring Ouzel alongside supporting traditional farming practices and maintaining the cultural value of an area.

Continued monitoring of Choughs in Wales will be essential in determining the best management approach in habitats with multiple goals. The specific factors driving changes in population size may be identifiable by comparing Chough populations with different trajectories, using robust monitoring data from surveys such as this, alongside more detailed demographic data from annual monitoring. This would provide a sound evidence base on which to prioritise conservation solutions.

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Manx Shearwater (Ben Porter)

GPS tracking Manx Shearwaters (*Puffinus puffinus*) from Bardsey's breeding colony

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Crynodeb

Canfuwyd arbenigo unigol o ran ymddygiad fforio mewn nifer gynyddol o dacsonau o anifeiliaid, ac mae ganddynt effeithiau pwysig ar ecoleg ac esblygiad rhywogaethau. Tra mae unigoliaeth o ran strategau bwydo yn gyffredin mewn anifeiliaid rheibus morwrol, mae ei ran mewn ffurfio dosbarthiad fforio mewn nifer o rywogaethau yn parhau'n aneglur. Yn yr astudiaeth yma, rydym yn defnyddio cofnodwyr System Leoli Fyd-eang (GPS) i astudio patrymau gofodol defnydd o'r cynefin morwrol mewn aderyn môr gyda dosbarthiad cyfyngedig, Aderyn-drycin Manaw (*Puffinus puffinus*), o'r safle nythu bedwaredd fwyaf yn y byd, Ynys Enlli, yn ystod tymor nythu 2017. Ymddengys bod gweithgareddau fforio yn ystod y cyfnod gori yn canolbwyntio ar ddyfroedd haenedig Ffrynt Môr Iwerddon (ISF) yng ngogledd-orllewin Môr Iwerddon, sy'n gyson â'r darganfyddiadau o safleoedd nythu eraill. Gwelwyd cymysgedd o fwydo lleol a theithiau hir i orllewin yr Alban yn ystod cyfnod magu'r cywion, gydag oedolion unigol yn arddangos ffyddlondeb cryf i safle fforio trwy ddychwelyd i bwyntiau pellaf tebyg dros nifer o deithiau bwydo. Efallai fod yr ymddygiad yma'n arwain at arwahanrwydd o ran lleoliad ac ymborth yn y rhywogaeth yma.

Summary

Individual specialisations in foraging behaviour have been discovered in a growing number of animal taxa and have important impacts on the ecology and evolution of species. Whilst individuality in feeding strategies is common in marine predators, its role in shaping foraging distributions among many species remains unclear. In this study, we use Global Positioning System (GPS) loggers to study spatial patterns of marine habitat use in a range-restricted seabird, the Manx Shearwater (*Puffinus puffinus*), from the world's fourth largest colony, Bardsey Island, during the 2017 breeding season. Foraging activity during incubation appeared concentrated around the stratified waters north-west of the Irish Sea Front (ISF) in the north-west Irish Sea, which is consistent with findings from other colonies. A mixture of local feeding and long-distance trips to western Scotland was discovered during the chick-rearing period, with adult birds demonstrating strong individual foraging site fidelity by returning to similar distal points over repeat feeding trips. This behaviour may present a potential driver of spatial and dietary segregation in this species.

Introduction

The Manx Shearwater is a 400-450g, long-lived pelagic seabird that breeds in dense colonies along the coasts of the North Atlantic and spends the winter off South America (Brooke 1990). Although classed as Least Concern by the IUCN, a significant proportion of the world's population (approx. 80%) breed at just a handful of coastal sites around Britain and Ireland (Mitchell et al. 2004). Manx Shearwaters demonstrate a variety of consistent behaviours typical of many seabirds: they form a strong, monogamous pair bond with their mate, show long-term fidelity to their nesting burrow (Brooke 1990) and are highly consistent in both the timing of their migration and the locations of

their overwintering sites off South America over multiple seasons (Freeman et al. 2013). Whether individual consistencies in foraging or diet exist within the breeding season is unknown. A wealth of tracking studies have taken place on this species since 2008, particularly focusing on some of the larger colonies such as Skomer in Pembrokeshire (e.g. Guilford et al. 2008; Dean et al. 2015; Shoji et al. 2015; Fayet et al. 2015; Tyson et al. 2017). However, whilst this species is very well-studied, there are still many gaps in our knowledge of its multi-colony use of marine habitats and important behaviours such as individual specialisations in foraging behaviour and diet.

The purpose of this study was to provide detailed information on the at-sea distribution of Manx Shearwaters breeding on Bardsey – the fourth largest colony in the world – and place this in the context of existing information on the marine habitat-use of the other large colonies bordering the Irish and Celtic Seas, including Skomer, Lundy, Copeland and Rhúm (Guilford et al. 2008; Freeman et al. 2011; Dean et al. 2015). We also provide the first assessment of individual foraging site fidelity in this species by comparing foraging sites (distal points of trips), foraging routes (nearest neighbour distance) and foraging effort (distance travelled) over repeat trips. By using GPS loggers to track the foraging movements of breeders, we will be able to identify potentially important feeding areas for this large colony and test the hypothesis that individual foraging and site fidelity exists in this species.

Methods

Study site

The study was carried out on Bardsey between June and August 2017. The island holds approximately 21,000 breeding pairs of Manx Shearwaters (Carter and Stansfield 2016), representing the fourth largest colony in Britain and Ireland after those of Rhúm (approx. 120,000 pairs), Skomer (approx. 316,000 pairs) and Skokholm (approx. 46,000) (Mitchell et al. 2004; Perrins et al. 2012). Although the movements from these latter colonies have been well-studied in recent years, knowledge of Bardsey's population, which has grown by approximately 6,000 pairs since 2010 (Carter and Stansfield 2016), is limited to a small number of incubating adults tracked in June 2013 by Spivey et al. (2014).

Shearwaters nest in underground burrows, where parents take turns to incubate their single egg in May and June, before sharing the duty of chick rearing from July to September (Brooke 1990). At the start of the breeding season 33 burrows were selected, which were already occupied by incubating breeders, permitted easy access to the nest chamber (i.e. within arm's reach), and were located within a short distance of each other to allow regular checks during the night when adults return to the island. Burrows were marked with small numbered pegs to allow relocation and continued monitoring over the breeding season.

GPS tracking

Ringing and tagging of wild animals and birds within the UK is strictly prohibited under the Wildlife and Countryside Act (1981), except for certain circumstances which have to be licensed. Under a Special Methods Licence granted by the British Trust for Ornithology (administrators of the British Ringing Scheme) Manx Shearwaters were fitted with global positioning system (GPS) data logger devices, as well as the usual individually identifiable numbered metal rings. The tags deployed were modified i-gotU GT-120 devices (Mobile Action Technology), sealed in a heat-shrink tube to make them waterproof (Fig. 1b) and were programmed to take locational fixes every 5 minutes. This interval was increased to 10 and 15 minutes on longer incubation trips to increase battery lifespan and maximize the proportion of the foraging journey recorded. Devices weighed 17.0g once sealed in the waterproof heat-shrink plastic, the overall weight representing 3.3 – 4.7% of adult body mass

(411g ± 33.4). The tags were secured to a small number of feathers on the mid- and lower back of the shearwaters using three strips of Tesa® tape (Fig. 1c). In total, 36 individuals were fitted with GPS devices between 1 June and 16 August 2017, with 12 of these birds tracked twice: once during the incubation stage and then again during the chick rearing stage. This totalled 48 deployments over the entire period.

Figure 1. Deployment of GPS data loggers on adult Manx Shearwaters. The devices were modified i-gotU GT-120 GPS data loggers (Mobile Action Technology) weighing ~17g. Loggers were de-constructed and sealed in heat-shrink plastic (b) and then attached to small number of feathers on the mid-back of birds using three strips of marine Tesa® tape (c & d). Processing of the bird and attachment took on average eight minutes.

Incubating adult shearwaters were captured by hand within their burrows during the daytime, fitted with a GPS device and then returned. Devices were retrieved by checking study burrows daily until the focal bird returned from a foraging trip. During chick rearing, tracking began once chicks exceeded a weight of 200g, a size recommended by studies on Skomer to avoid the most sensitive development stage of chicks (Dean et al. 2015). Adults were captured as they returned to the colony during the night; small pegs were placed vertically in study burrow entrances, which were knocked

over when birds entered and 20-30-minute inspection visits then allowed returning birds to be detected. Burrows were blocked for 30 minutes after the parent's return to allow the adult to feed its chick, before removing the adult and fitting the GPS logger device.

Testing for device effects

GPS tagging has on occasion been shown to have negative impacts on the survival and reproduction of animals such as birds (Bodey et al. 2017), but we found that breeding success in our 33 study burrows (0.79 chicks/pair) was 14% greater in comparison to 127 control burrows (0.65 chicks per pair) where no tracking was carried out. Similarly, we found no significant difference in the mean growth rate (g/day^{-1}) of 24 chicks whose parents were tracked (4.90 s.e. ±10.62) to 21 control chicks (4.83 s.e. ±8.11) where no tracking was carried out (2 sample t-test: t (336)=0.94, p=0.35). Overall, there was no evidence to suggest that the tagging procedure caused adverse impacts to chick condition or breeding success.

Analysis of tracking data

All data-processing and statistical analyses were conducted using the statistical package R 3.2.3 (R Core Team, 2015). Data were first filtered to remove erroneous fixes based on unrealistic locations and flight speeds (>90 km/h; Guilford et al. 2008). Foraging trips were split into complete and partial tracks, as the battery of some GPS loggers ran out before the end of foraging trips in some deployments. For each complete GPS track, we calculated: (a) overall track length (km), (b) furthest location from the colony (km), (c) terminal latitude and longitude of foraging trips, and (d) duration of foraging trips (days). We visually examined tracks to identify likely foraging areas (where GPS tracks were highly contorted) and commuting routes to and from Bardsey.

Inter-colony comparison of at-sea movements

Using the trip metrics outlined above and visual estimation of foraging areas, we were able to compare the at-sea behaviour of Bardsey's shearwaters to those from other colonies across its core breeding range. In particular, we present our results alongside those from an inter-colony tracking study by Dean et al. (2015), which tracked shearwaters from Skomer, Copeland, Rhúm and Lundy between 2009 and 2011. This study filtered data using a similar methodology and calculated the same measures for quantifying foraging movements, enabling a robust comparison.

Individuality of foraging behaviour

To examine individual consistencies in foraging behaviour, we focused on tracking data from the chick-rearing stage, where we acquired multiple foraging trips (2-5 repeat trips per bird) from 13 adults. We excluded long foraging trips (maximum distance >200km; trip duration >3 days) from the analysis, as these long trips are often carried out by adults to recover their own body condition, and so birds may use different areas, habitats and even food types to those when provisioning chicks (Shoji et al. 2015; Tyson et al. 2017). GPS fixes within a 3km radius of the colony were removed, as birds often congregate in non-foraging rafts close to the island at dusk prior to returning to their nests (Brooke 1990; Guilford et al. 2008; Tyson et al. 2011). The resulting dataset included a total of 38 repeat tracks, from which we calculated three measures to assess individuality in foraging behaviour: (i) foraging route fidelity, (ii) foraging site fidelity, and (iii) foraging effort.

Foraging route fidelity

Individual route fidelity was calculated using nearest neighbour distance (NND). This analytical technique produces a quantitative estimate for the similarity between two GPS tracks. For any pair of tracks, it calculates the distance (in km) from a point on one track to a neighbouring point on a

comparison track. This process is then carried out for all points on the pair of tracks, and then an average is produced to quantify the NND for the two trips: a high NND value indicates dissimilar routes, whilst a low NND indicates similar routes.

We calculated the average NND for all repeat foraging trips within individuals and among all individuals. We then used linear mixed models (LMMs) to investigate whether fidelity of foraging routes was significantly higher at an individual level than at the 'population level'. We included pair as a random effect and compared each model to a null model (intercept only) using likelihood-ratio tests (LRTs). NND artificially increases if the difference in the trip length between two tracks varies widely, and so this variable (difference in trip length) was included as a fixed effect. NND was square-root-transformed to obtain normality for the analysis.

Foraging site fidelity and foraging effort

We used the terminal point of a foraging trip as a measure of foraging site fidelity. The latitude and longitude of this point was estimated for each foraging trip, and then the similarity of these points for repeat tracks was compared both within and among individuals. Visual analysis of the tracking data revealed that, whilst foraging could occur at any point along a shearwater's trip, feeding often took place close to a bird's furthest location from the colony.

Following Patrick et al. (2014) and Votier et al. (2017), we quantified foraging effort using three key variables: (i) overall distance travelled (km); (ii) distance to the furthest point from the colony (km); and (iii) total trip duration (days).

To examine whether individuals demonstrated any consistency in foraging sites or effort, we used the repeatability package rptR in R (Nakagawa and Schielzeth 2010). This package calculates the repeatability (r) of each measure, its associated standard error and p-value by testing the null hypothesis that within-individual variance equals among-individual variance (0 = low repeatability, 1 = high repeatability). Track length and distance to distal point were log transformed to achieve normality, and trip duration was natural-square-root-transformed.

Results

Foraging trips

We obtained data for a total of 58 foraging trips from 22 individuals during incubation and chick rearing (1 June – 21 August 2017). A total of 14 birds returned without a GPS logger, and eight of the retrieved GPS devices failed to record any data after running out of battery before incubating birds left their burrows. Three birds tracked during the incubation period were 'prospecting' birds that did not lay an egg, and tracks from these non-breeding birds were excluded from our main results. Most of the resulting tracks (93%) were complete and were used to calculate trip metrics for each breeding stage (Table 1), with tracks plotted individually in Fig. 2.

At-sea behaviour

Overall, foraging activity was concentrated in the Irish Sea to the north-west of Bardsey over the entire period (Fig. 2a,b), in a region where significant inter-colony overlap in feeding is known to occur (Dean et al. 2015). The use of this region, close to an area known as the Irish Sea Front (ISF), was greater during incubation than chick rearing, with more locally-concentrated foraging activity noted during this latter period (Fig. 2b; Table 1). Five birds during chick rearing also underwent long-range trips to western Scotland, reaching as far west as the Outer Hebrides and the Isle of Rhúm to the north (Fig. 2b).

During the incubation tracking period (3 June – 2 July), foraging trips were relatively long, both in length and duration (median track length 1,163km; median duration 5 days). They were shorter than recorded on Skomer (median track length 1,517km) but marginally longer than Copeland (median track length 1,031km) (Table 1). This appears closely related to the distance of these colonies to the waters surrounding the Irish Sea Front region between Dundalk (Ireland) and the

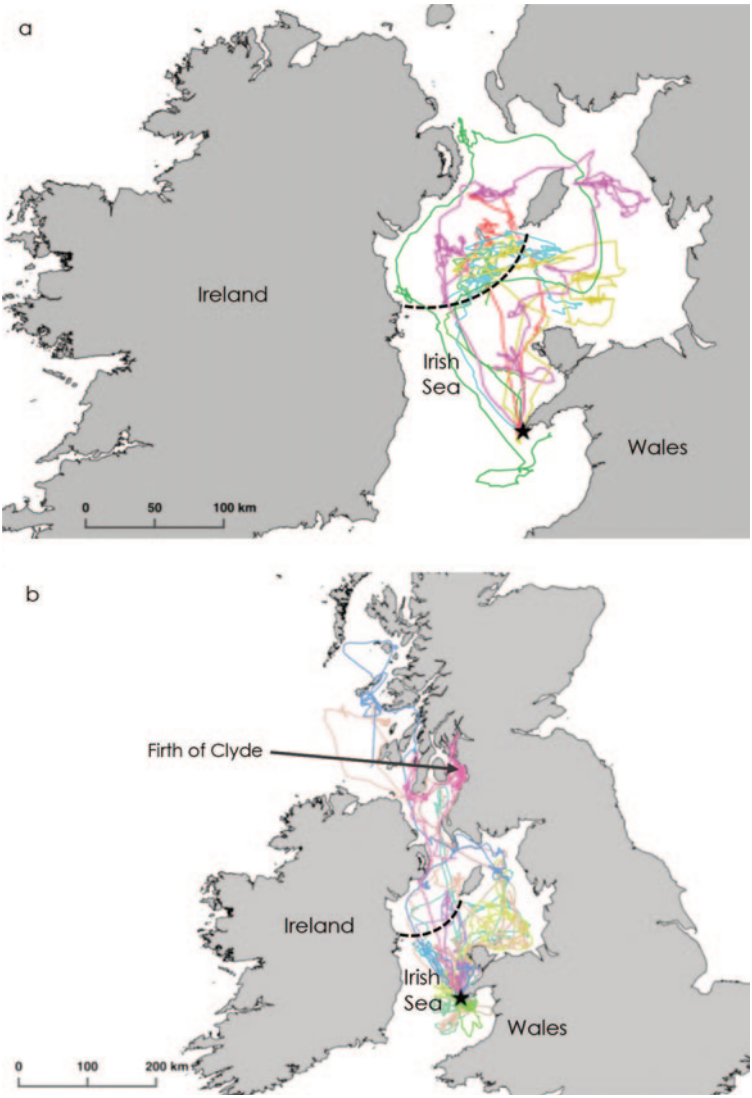

Figure 2. **(a & b)** Raw GPS tracks of Manx Shearwater foraging movements from Bardsey Island (marked with dark star) in the Irish Sea during the 2017 breeding season. Six were incubating adults (a) and 14 were chick-rearing adults (b). Tracks are coloured individually, and the approximate position of the Irish Sea Front is depicted by the curved dotted line.

Figure 2. **(c & d)** Raw GPS tracks of Manx Shearwater foraging movements from Bardsey Island (marked with dark star) in the Irish Sea during the 2017 breeding season.
The two longest and most surprising tracks of the whole project, where one bird (c) visited Morecambe Bay then continued its journey northward as far as Rhúm and the Outer Hebrides. Another bird (d) went as far up the River Clyde as Greenock and Dunoon and then spent several days off the Ayrshire coast around Troon.

Isle of Man, which was visited on 100% of short trips (<200km) from Bardsey, 64% of short trips from Copeland and 73% of longer trips (>200km) from Skomer (Table 1). Additional evidence of foraging activity was noted around the Mull of Galloway, between the Isle of Man and Morecambe, and to the north-east of Anglesey, with only one trip recorded to the south of the island (Fig. 2a).

During chick rearing (1–22 August), 91% of trips were <200km from the colony, with shorter track lengths (median 208km) and trip durations (median 1 day) than during incubation. Foraging activity appeared concentrated locally to Bardsey, particularly in the waters south-west of Anglesey and in Liverpool Bay off North Wales (Fig. 2b). This local foraging is consistent with findings from the four colonies studied by Dean et al. (2015), where chick-rearing trips were similarly short in length and concentrated within 200km of each colony (Table 1).

Five chick-rearing adults carried out long-distance trips to western Scotland, the longest covering 2,000km over nine days, rafting off the Isle of Rhúm for one night at a maximum distance of 502km from Bardsey (Fig. 2b). During these long-range trips, concentrated feeding activity was observed in the Firth of Clyde and the waters between the Scottish islands of Tiree and Islay (Fig. 2b), and 75% of these trips also visited the ISF. Similar long-distance trips were recorded by Dean et al. (2015) from Skomer, Lundy and Rhúm (Table 1), with feeding taking place almost exclusively around the ISF for birds from Lundy and Skomer (Table 1). The foraging activity in Scotland we observed overlaps more with areas used by the colonies of Copeland and Rhúm (see Dean et al. 2015), which are situated much closer geographically.

Colony (distance to ISF, km)	Period	Short or long trip	% short trips	% trips to ISF	Track length (km)	Max dist. (km)	Trip dur. (d)
Copeland (120)	Incub.	S	95	64	**1031** (408 - 1552)	**119** (73 - 152)	**7** (5-9)
		L		50			
	Chick-R	S	100	44	**255** (129 - 545)	**56** (27 - 93)	**1** (1 -3)
		L		-			
Bardsey (130)	Incub.	S	67	100	**1163** (943-1370)	**161** (148-195)	**5** (4-7)
		L		50			
	Chick-R	S	91	5	**208** (116-352)	**51** (28-98)	**1** (1-2)
		L		75			
Skomer (215)	Incub.	S	35	0	**1517** (925 - 2117)	**254** (176-295)	**8** (7-11)
		L		73			
	Chick-R	S	85	0	**297** (203 - 581)	**86** (61 - 134)	**1** (1-2)
		L		100			
Lundy (280)	Chick-R	S	82	0	**305** (169 - 592)	**49** (29 - 104)	**2** (1 - 3)
		L		83			
Rhúm (375)	Chick-R	S	92	0	**184** (128 - 274)	**35** (29 - 73)	**1** (1 -1)
		L		60			

T**able 1.** Metrics of Manx Shearwater trips from Bardsey Island (2017) and four other colonies in the core breeding range (tracked between 2009-2011 by Guilford et al, 2015).

Metrics are given for each stage of the breeding season and are pooled across years. Colony and approximate distance to the Irish Sea Front (ISF); period (chick rearing [Chick-R] and incubation [Incub.]; % of trips that were short distance (S, < 200km); % of both short and long distance trips (L, >200km) that were to the ISF area; and medians (with interquartile ranges) for overall track lengths, maximum trip distances and trip durations are included.

Individuality in foraging behaviour

We obtained 36 repeat trips from 13 adults between 1 and 21 August (Fig. 4), with a median of three repeat trips per bird (range 2 – 4). Whilst there was variability in their spatial and directional consistency, some shearwaters were highly consistent in their departure directions and foraging areas; other birds showed little consistency in their routes or foraging sites, with GPS tracks for these birds showing less evidence of foraging activity (Fig. 4).

Foraging route fidelity

Mean NND for repeat trips within individuals (20.4 s.e. ± 2.25) was very similar to mean NND amongst all individuals (30.5 s.e. ± 0.08; Fig. 3) and this was not statistically different (LRT: df = 4, χ^2 = 0.69, p = 0.41).

Foraging site fidelity and repeatability of foraging effort

During repeat chick-provisioning trips, individuals were highly repeatable in their distal latitude and longitudes (Table 2). Whilst distal points of foraging trips varied from one individual to the next (Fig. 4), some important shared areas were also apparent, including the waters around the ISF, the waters of Liverpool Bay and the sea to the south-west of Anglesey (Fig. 4).

Foraging effort (total distance and distal point from colony) among the individuals was highly variable and showed no significant repeatability, although duration of foraging trips was highly repeatable (Table 2).

Trip metric	Chick-rearing adults (n = 13)
foraging site fidelity	
longitude of distal point (DD)	**0.33 ± 0.18 (0, 0.64)****
latitude of distal point (DD)	**0.50 ± 0.17 (0.10, 0.75)*****
foraging effort	
total distance travelled (km)	0.24 ± 0.16 (0, 0.56)
distance to distal point (km)	0.28 ± 0.17 (0, 0.59)
duration of trip (hrs)	**0.35 ± 0.17 (0, 0.65)****

Table 2. Repeatability values (r ± s.e., with 95% Cis in parentheses) for foraging site fidelity (decimal degrees) and foraging effort (0 = low repeatability, 1 = high repeatability) of chick-rearing Manx Shearwaters on Bardsey Island.

Birds show highly repeatable distal latitude and longitudes during chick-provisioning foraging trips. Foraging effort, however, was highly variable and showed low repeatability. Trip duration was highly repeatable. Significantly repeatable foraging behaviours are indicated in bold and asterisks indicate significance levels (** = p< 0.05, *** = p< 0.01).

Discussion

This study successfully tracked the movements of 24 Manx Shearwaters during the 2017 breeding season on Bardsey (June-August), allowing a detailed insight into their at-sea behaviour and foraging activity. Our results provide the first evidence of individual foraging site fidelity in breeding Manx Shearwaters, with birds repeatedly returning to the same distal points over consecutive chick-provisioning feeding trips (Fig. 4; Table 2). Birds showed little consistency in their foraging routes (Fig. 4), however, and low repeatability in foraging effort (Table 2). Apart from insights into individual-level behaviours, our results provide valuable information on the colony's population-level use of

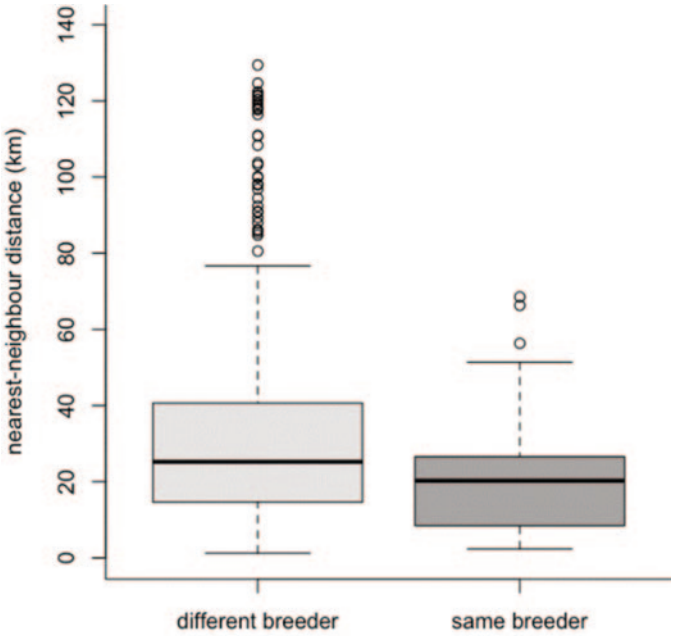

Figure 3. Variation in NND (s.d. ± in km) within individual breeders was very similar to variation in NND among all breeders. This suggests no individual consistency in the foraging routes taken by adults during chick-provisioning trips from Bardsey.

the pelagic environment: breeders during the incubating stage foraged almost exclusively around the Irish Sea Front, while feeding activity of chick-rearing adults was concentrated more locally (<200km) to the island (Fig. 2). Five birds underwent striking long-distance trips to the Firth of Clyde and western Scotland during chick rearing, the longest travelling over 2,000km to the Outer Hebrides (Fig. 2b). The potential causes and consequences of the behaviours we discovered are discussed below.

Foraging in relation to the Irish Sea Front

Recent studies have revealed the importance of the waters around the Irish Sea Front (ISF) as a feeding area for Manx Shearwaters and other seabirds during the breeding season (Guilford et al. 2008; Dean et al. 2015; Fayet et al. 2015), supporting its designation as a Special Protection Area (SPA) in 2017 (JNCC seabirds). A tracking study by Dean et al. (2015) found that shearwaters from

Figure. 4. (See p31) Repeat foraging trips of chick-provisioning Manx Shearwaters (n = 12) breeding on Bardsey (marked with black star) in summer 2017 (1 – 22 August).

Some breeders demonstrate a high degree of individual foraging site fidelity (e.g. a - d), as confirmed by significantly repeatable distal trip locations (Table 2), and these birds also tended to follow consistent routes to their foraging sites. Other birds show variable foraging routes and locations over repeat trips, but still appear to travel in a generally consistent direction and broader-scale area to feed. Whilst most foraging activity occurred within 100km of the colony (a – h), some birds foraged as far afield as the Firth of Clyde, Liverpool Bay and the Irish Sea Front (i – l), even during chick-provisioning trips that were typically <2 days in duration (Table 2). Distal points are marked with a black dot, and the number of repeat trips is shown for each bird.

n = 4
e
n = 2
f
n = 3
g
n = 2
h
n = 4
i
n = 3
j
n = 3
k
n = 3
l

Lundy, Skomer, Copeland and Rhúm overlapped in their use of this area, with 64% of short trips (<200km) from Copeland and 73% of long trips (>200km) from Skomer visiting the ISF during incubation (Table 1). We found similar results from Bardsey's colony, with all short trips during incubation and 75% of long trips during chick rearing spending time here (Table 1), providing further evidence that concentrated inter-colony overlap in foraging activity occurs within this highly productive area of the Irish Sea (Stone et al. 1994).

Whilst clearly an important resource for breeding shearwaters, there may be a trade-off between the benefits of feeding here and the energetic costs of travelling to this spot, with Dean et al. (2015) finding a decline in visits to the ISF with increasing colony distance. Given Bardsey's position some 130km closer to the ISF than Skomer and Skokholm, it might be expected that birds benefit from this proximity, for example through increased breeding performance or adult condition. Investigating this trade-off further amongst Celtic Sea colonies and those further afield would highlight the exact importance of this restricted area.

At-sea movements during chick rearing

Foraging in the chick-rearing period took place much closer to the colony (median max. distance 51km; median track length 208km), as is typical of shearwaters, auks and other seabirds constrained by the need to regularly return to their nest and feed their chick (Shoji et al. 2015). This local foraging activity highlights the importance of the waters surrounding Bardsey for chick-provisioning adults, although we also recorded striking long-distance journeys (1,200km – 2,000km) in five birds, which spent up to nine days at sea and visited areas such as the Firth of Clyde in western Scotland (Fig. 1b). This finding is consistent with a behaviour termed the dual-foraging strategy, employed by many species of Procellariformes, including the Manx Shearwaters, Cory's Shearwaters (*Calonectris borealis*) and Sooty Shearwaters (*Puffinus griseus*) (Weimerskirch 1998; Magalhães et al. 2008; Shoji et al. 2015). This strategy allows parents to combine short foraging trips to local areas (shown to maximise feeding frequency to chicks) with longer trips to more productive areas (allowing parents to recover their own body condition). Whilst it might be expected that adults would carry out periods of self-fuelling locally, thus avoiding the energetic cost of flying hundreds of kilometres further afield, areas close to the colony are likely to be highly exploited and offer average-to-low rewards (Weimerskirch 2007). The long distances covered by self-feeding adults in our study supports the hypothesis that these trips allow adults to visit more distant areas with potentially higher productivity and allow access to higher quality prey items (Einoder et al. 2013; Shoji et al. 2015). In this study, the Firth of Clyde (Fig. 2b) appeared to be the most important site for birds on self-feeding trips, which contrasts to the findings from Skomer where most birds tended to visit the Irish Sea Front (Dean et al. 2015; Shoji et al. 2015). It might be that there was higher productivity in the Firth of Clyde than the Irish Sea Front in 2017, especially later in the season when this tidal front begins to dissipate (Stone et al. 1994).

Individual foraging site fidelity during chick rearing

Individual foraging site fidelity (IFSF), where individuals repeatedly use the same area for feeding, is a form of spatial foraging consistency that might arise because of individual differences in preferred foraging behaviour, habitat or prey (Patrick et al. 2014; Phillips et al. 2017). For colonial, central place foragers such as Manx Shearwaters, this behaviour is thought to be important by reducing intra-specific competition (Bolnick et al. 2002). During the chick rearing period, for example, adult shearwaters are restricted to feeding close to the colony where productivity is low and the density of conspecifics is high (Dean et al. 2015). By foraging in different locations, at different depths or on alternative prey to conspecifics, birds can

partition their niches and alleviate competition, as has been found in species such as Gannets (*Morus bassanus*) (Patrick et al. 2014) and King Cormorants (*Phalacrocorax atroceps*) (Kato et al. 2000). Further work would be needed to examine the underlying mechanisms of this individual specialisation, such as whether individuals specialise in their prey choice or foraging habitat.

It is hypothesised that the magnitude of individual foraging specialisations may be positively correlated with the level of intra-specific competition (Svanback and Bolnick 2007; Araujo et al. 2011), and so it might be predicted that the occurrence of IFSF in Manx Shearwaters is greater in colonies with higher breeding populations, such as Rhúm (120,000 pairs) and Skomer (316,000 pairs) (Mitchell et al. 2004; Perrins et al. 2012). A study examining this relationship in seven Gannet colonies across the North Sea revealed no relationship between adult IFSF and colony size, although intra-specific competition in this species is thought to be less important in governing foraging distributions (Votier et al. 2017). Conducting a similar inter-colony comparison across the shearwater's core breeding range would present a novel insight into the drivers of this individuality.

Although intra-specific competition may play a role in the individual foraging we observed, there are other factors that might contribute to this behaviour. One explanation is linked to search behaviour: short-term fidelity to feeding sites might represent birds employing a win-stay-lose-switch foraging strategy (Davoren et al. 2003). For example, if a bird encountered a productive feeding area during a foraging trip, it might return to this site until the prey aggregation disperses. Since the shearwaters in our study were tracked over a very short time-period, this win-stay-lose-switch strategy might account for the behaviour we observed. However, IFSF has been found to persist across breeding seasons in species such as Gannets, indicating that birds might not just be responding to short-term feeding opportunities (Votier et al. 2017). Furthermore, marine predators such as Manx Shearwaters feed on prey which is often distributed in predictable patches associated with persistent oceanic fronts and upwellings (Weimerskirch 2007; Patrick et al. 2014; Wakefield et al. 2015). It has been suggested that site familiarity in such predictable environments is an alternate cause of IFSF: by foraging in a familiar location, birds might acquire a competitive advantage by gaining information specific to that site, and this may be less risky than searching for a new site that offers higher rewards but increases energetic costs (Yoder et al. 2004; Piper 2011; Wakefield et al. 2015). Tracking birds for longer periods across multiple breeding seasons would allow us to reveal the exact nature of IFSF in this species.

Whilst we found significant consistency in the foraging locations used by chick-rearing adults, there was low repeatability in their foraging routes and foraging effort (Table 2). This variability might reflect differences in the weather conditions across the tracking period, particularly in wind speed and direction. Procellariform seabirds often adopt a dynamic soaring flight style, making use of cross-winds to reduce the energetic costs of flying at sea. They are therefore highly influenced by the strength and direction of the wind, which might alter their trajectories according to the conditions (Spivey et al. 2014; Gibb et al. 2017). Lastly, we found significant repeatability in the duration of foraging trips within individuals (Table 2), which likely reflects the need for adults to return regularly to provision their chick (typically every 1-3 nights during the early and mid-chick-rearing period; Brooke 1990; Shoji et al. 2015). Furthermore, shearwaters only return to the colony during the night to avoid predation (Brooke 1990), which would result in relatively concentrated periods of return and departure from the colony, further explaining the consistency we observed.

Wider implications

Seabirds are one of the most threatened groups of marine vertebrates (Croxall et al. 2012; Spatz et al. 2014), and so understanding their behaviour at sea is crucial for informing appropriate

conservation strategies. We found that breeders were particularly reliant on the ISF on feeding trips during incubation, providing further evidence of the importance this area holds for a significant proportion of the species' global breeding population (Dean et al. 2015). Conversely, the use of local areas during the chick-provisioning period highlights the need for increased levels of protection in these areas, which are likely to be used by other vulnerable seabirds breeding on Bardsey. Individual-level specialisations such as IFSF have far-reaching consequences for the persistence of populations, as they can result in large differences in how individuals interact with threats such as fisheries and changes to the marine environment. However, variability in the use of foraging sites at a population level might present a level of phenotypic plasticity that increases the ability of populations to buffer against the potentially deleterious impacts of environmental change (Araujo et al. 2011).

Conclusions

In summary, the study found that Manx Shearwaters breeding on Bardsey utilised a broad variety of areas within the marine environment during the 2017 breeding season. During incubation, off-duty adults appeared particularly reliant on the waters associated with the Irish Sea Front (Fig. 2a), providing further evidence for the importance of this area for several of the country's largest colonies (Dean et al. 2015). Chick-rearing adults combined a mixture of short foraging trips to local waters with long-distance trips to areas in western Scotland (Fig. 2b). This behaviour is consistent with a dual foraging strategy, where parents balance the need to regularly provision their chick with their own need to recover body condition by accessing more productive feeding grounds further afield (Shoji et al. 2015). We also discovered the first evidence of individual foraging site fidelity in this species, with chick-rearing adults returning to similar distal points over consecutive feeding trips (Fig. 4). This strategy might arise as a means of reducing high intra-specific competition in local waters (Araujo et al. 2011; Patrick et al. 2014), or might be driven by the energetic benefits of maintaining familiarity with a feeding site (Piper 2011; Wakefield et al. 2015). More work is needed to reveal exactly how important this behaviour is in driving the spatial distribution discovered in this species and other marine predators.

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Year-round movements of Greenland White-fronted Geese (*Anser albifrons flavirostris*) ringed in Wales in winter 2016/17 revealed by telemetry

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Crynodeb

- Daliwyd pedair ar ddeg o Wyddau Talcen-wen yr Ynys Las (*Anser albifrons flavirostris*) ar 4 Rhagfyr 2016 ar aber Afon Dyfi, Ceredigion. Gosodwyd coleri GPS ar ddwy fenyw mewn oed a choleri plastig ar ddeg arall.
- Symudodd un fenyw gyda choler GPS, ei chymar oedd yn gwisgo coler blastig, ac efallai ddau unigolyn heb goler, o'r aber ar 12 Rhagfyr 2016 i Wexford yn ne-ddwyrain Iwerddon, gan ddychwelyd i afon Dyfi ar 9 Mawrth 2017. Arhosodd yr adar eraill oedd yn gwisgo coleri ar afon Dyfi trwy gydol gaeaf 2016/17.
- Credir i'r holl adar adael afon Dyfi gyda'r nos ar 2 Ebrill 2017, gan gyrraedd eu man ymgynnull yn ne Gwlad yr Iâ erbyn 3 Ebrill. Treuliodd y ddwy ŵydd gyda choleri GPS bron fis ar iseldir de Gwlad yr Iâ cyn gadael am orllewin yr Ynys Las ar 1 a 3 Mai a chyrraedd gorllewin yr Ynys Las ar 6 Mai.
- Treuliodd y gwyddau gyda choleri GPS yr haf rhwng 67.8°N a 68.2°N. Awgryma'r data lleoliad fod y ddwy wedi dodwy wyau, un wedi eu gori'n llwyddiannus hyd ddeor (a gadarnhawyd yn ddiweddarach trwy weld cywion gyda hwy yn eu man ymgynnull yn yr hydref yn ne Gwlad yr Iâ) a'r ŵydd arall wedi rhoi'r gorau i ori wedi pedwar diwrnod.
- Gadawodd y gwyddau gyda choleri GPS orllewin yr Ynys Las ym mis Medi cyn treulio 35 a 56 diwrnod yn ne Gwlad yr Iâ. Gadawsant Wlad yr Iâ ddiwedd Hydref/Tachwedd, gydag un yn dychwelyd i afon Dyfi a'r llall yn gaeafu ar Coll (Argyll).
- Er bod Gwyddau Talcen-wen yr Ynys Las dan amddiffyniad gwaharddiad gwirfoddol ar saethu gan glybiau hela Cymru, yn cynnwys gwaharddiad o 40 mlynedd ar afon Dyfi, mae'n parhau'n gyfreithlon i'w saethu a gallent gael eu saethu yn rhywle arall yng Nghymru gan rywun heb fod yn aelod o glwb. Yn yr Alban, Iwerddon, Gwlad yr Iâ a'r Ynys Las, mae amddiffyniad cyfreithiol, ac felly dim ond mewn camgymeriad am rywogaeth arall neu'n anghyfreithlon y gellid eu saethu.

Summary

- Fourteen Greenland White-fronted Geese (*Anser albifrons flavirostris*) were caught on 4

December 2016 on the Dyfi Estuary, Ceredigion. Two adult females were marked with GPS collar tags and ten were marked with plastic neck collars.

- A GPS tagged female, its collared mate and possibly two unmarked individuals moved from the estuary on 12 December 2016 to Wexford, SE Ireland, and returned to the Dyfi on 9 March 2017. The other marked birds remained on the Dyfi throughout winter 2016/17.
- The entire flock probably left the Dyfi on the evening of 2 April 2017, arriving in their spring staging area in south Iceland by 3 April. The two GPS-tagged geese spent nearly a month in the southern lowlands of Iceland before departing for west Greenland on 1 and 3 May and arriving in west Greenland on 6 May.
- The GPS-tagged geese spent the summer between 67.8°N and 68.2°N. Location data suggested that both GPS-tagged birds probably initiated clutches, one incubating successfully through to hatching (subsequently confirmed by live sightings of associated goslings in their autumn staging area in southern Iceland) with the other goose ceasing incubation after four days.
- The GPS-tagged geese left west Greenland in September before spending 35 and 56 days in south Iceland. They left Iceland in late October/November with one returning to the Dyfi, whilst the other wintered on Coll (Argyll).
- Although Greenland White-fronted Geese are protected by a voluntary ban by Welsh hunting clubs, including a 40 year such ban on the Dyfi, the population remains legal quarry and vulnerable to being shot elsewhere in Wales by anyone without club membership. The population is legally protected from shooting in Scotland, Ireland, Iceland and Greenland and therefore could only be shot mistakenly for other species or illegally there.

Introduction

White-fronted Geese have a circumpolar distribution. There are currently four recognised races of the Holarctic Greater White-fronted Goose (*Anser albifrons*), two of which, European White-fronted Goose (*A.a.albifrons*) and Greenland White-fronted Goose (*A.a.flavirostris*) occur in Europe, the latter being endemic to Britain and Ireland during winter. Numbers of Greenland White-fronted Geese have been declining by c.3.5% p.a. since the late 1990s, and the global population has now decreased by c.40% to 20,556 individuals in 2016/17 (Fox et al. 2017). In Wales, numbers fell from possibly over 1,100 wintering birds to fewer than 150 in the twentieth century (Fox and Stroud 1985). In Wales, a small and declining flock winter on the Dyfi Estuary / Aber Dyfi Special Protection Area (SPA), and adjacent pastures (hereafter Dyfi), which now constitutes the only regularly monitored flock in the principality. The Dyfi flock has declined at a faster rate than the global population, from 167 birds in 1998/1999 to 26 birds in 2017/18 (Fig. 1). This may suggest that environmental conditions within the estuary, perhaps of lesser quality than previously, and/or anthropogenic factors (such as excessive disturbance), may lead individuals to either abandon or undertake premature emigration from the site during winter.

As a declining endemic population, the Greenland White-fronted Goose is UK Red Listed , on the Welsh red list of Birds of Conservation Concern (Johnstone and Bladwell 2016), classified as globally Endangered, listed as an Annex 1 species (EU Birds Directive (2009/147/EEC1), and is subject to a recent African Eurasian Waterbird Agreement (AEWA) International Single Species Action Plan (Stroud et al. 2012). A series of years with low reproductive success appears to be responsible for the global decline, although the cause of this remains unproven. Breeding success has been shown to be negatively correlated with spring precipitation during April and May (typically falling as snow) on their breeding grounds. Recent work showed that cohorts of birds encountering a series of springs with such poor environmental conditions on their breeding grounds were more likely to show delayed age of first successful reproduction than those that did not, suggesting a cumulative effect to individuals exposed to a series of springs with bad weather conditions (Weegman et al.

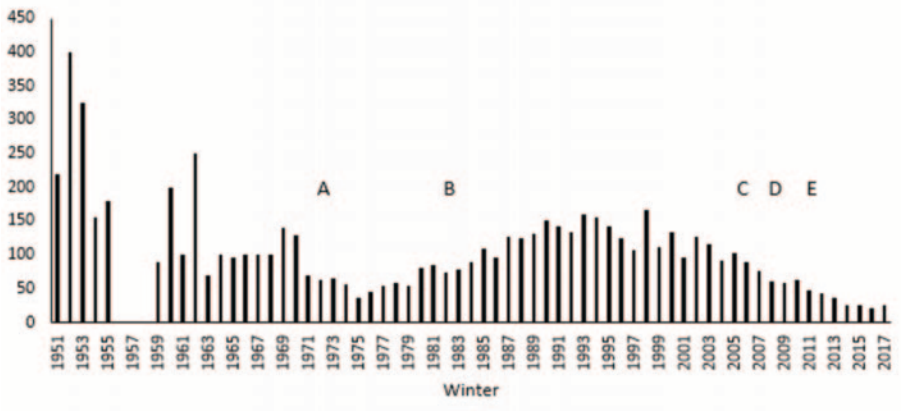

Figure 1. Maximum winter counts of Greenland White-fronted Geese recorded on the Dyfi Estuary 1951 to 2017. R. Jones/Greenland White-fronted Goose Study (GWGS) data.
http://greenlandwhitefront.org/gb-site-inventory/england-wales/78-dyfi-estuary-dyfed/
Timeline of protective measures: A – Voluntary shooting ban on the Dyfi Estuary (1972). B – Protection from hunting in Scotland and Ireland (1982/83). C – Protection from hunting in Iceland (2006). D – Protection from hunting in Greenland (2009). E - Voluntary shooting ban in wildfowling clubs in rest of Wales (2012).

2016).

To provide a sound evidence base for future management options for Greenland White-fronted Geese on the Dyfi, the Wales Greenland White-fronted Goose partnership was established in 2015 (see acknowledgments for partner organisations). Funding from the Welsh Government was awarded to Natural Resources Wales (NRW) to initiate Greenland White-fronted Goose research in winters 2015/16 to 2017/18. One aim of this work was to catch and fit Global Positioning System (GPS) tags on Greenland White-fronted Geese on the Dyfi to determine winter field use and habitat selection by the geese within the estuary (reported in Green et al. 2017). Another aim was to map the location and movements of the birds wintering on the Dyfi, outwith the estuary, for the first time, particularly where the geese stage in Iceland and where they breed.

On the winter quarters, Greenland White-fronted Geese are considered highly site faithful to their winter quarters, although this was based on birds marked at Wexford in SE Ireland (Wilson et al. 1991, Warren et al. 1992). Marking birds on the Dyfi would confirm if this was also the case for the birds wintering in Wales. We know the departure of geese from their winter quarters in Wexford in spring has advanced dramatically in recent years, yet departure from Iceland to Greenland has not (Fox et al. 2014). The use of GPS tags would also enable the timing of movements of the Dyfi flock to be investigated and compared to those wintering in Ireland.

Thus, in this paper, we examine the year-round movements of the tagged Greenland White-fronted Geese marked in this study during winter 2016/17 to the beginning of winter 2017/18. We also investigate the timing of the movements, the location and duration of the spring and autumn stop-overs in Iceland, evidence of breeding attempts and identify areas where the geese may be vulnerable to being shot.

Methods

Capture and ringing

Fourteen Greenland White-fronted Geese were caught in a field, by cannon-netting, on the Dyfi (52.5°N 3.9°W) on 4 December 2016. The catch comprised 12 adults (seven males and five females) and two first-winter birds (both females). GPS tags (Ecotone Telemetry) attached to plastic neck collars were fitted to two of the adult females (total mass of collar and tag 30g, ~1.3% of body mass). The tags, and individual geese, were coded WHIT01 and WHIT02. Ten other geese were fitted with orange plastic neck collars bearing engraved black three symbol alpha-numeric codes to aid subsequent recognition of individuals in the field. The codes can be read with a 60x zoom telescope at up to 250m.

Observations of the individually marked Greenland White-fronted Geese revealed that the two GPS tagged individuals were paired to collared adult males, but neither pair were observed with attendant goslings (first-winter birds) during capture or subsequently throughout the winter 2016/2017.

Collection and analysis of telemetry data

Location data from the GPS tags were retrieved via the Short Message Service (SMS) through the Global System for Mobile Communications (GSM) mobile phone network. The tags provided a minimum of two locations per day (midnight and noon) but up to six locations per day (once every four hours from midnight) when battery power allowed. In areas with no GSM service, the tags accumulated stored data and downloaded these data when the bird next moved to an area with GSM coverage. The GPS devices provided highly accurate location data, with up to 95% of data accurate to within 10m depending on the quality of the signal (Lech Iliszko, Ecotone, pers. comm.).

Results

Within-winter movements

GPS data showed that WHIT02 left the Dyfi eight days after capture, on 12 December 2016, with its collared mate and probably two other unmarked individuals, crossed the Irish Sea and arrived in a field near Dunleer, Ireland (53.8°N 6.3°W), a known wintering site for Greenland White-fronted Geese, on the same day. They then flew south to Wexford (52.3°N 6.4°W), where up to 7,200 Greenland White-fronted Geese wintered in 2016/17 (Fox et al. 2017), and the four geese were seen on 26 December 2016 (A. Walsh, pers.obs). The GPS data showed that WHIT02 fed daily on fields on the North Slob and roosted on Raven Point. On 9 March 2017, it flew northeast across the Irish Sea and stopped off near Porthmadog, Gwynedd (52.9°N 4.1°W), before moving back to the Dyfi later that day (Fig. 2).

WHIT01 and the other marked Greenland White-fronted Geese stayed on the Dyfi throughout the remainder of the winter. Collective observations of WHIT01 in the field by MG, CM and RJ, suggested that it was almost always with the whole flock of Greenland White-fronted Geese, and thus the GPS locations of WHIT01 were thought to represent the winter site use of the entire flock whilst on the estuary. Based on location data at midnight and noon, the flock spent 72% of days (5 December to 2 April) within the Dyfi Special Protection Area (SPA) (see Green et al. 2017 for details). The maximum count of Greenland White-fronted Geese prior to the catching event was 18 birds. After WHIT02 and three others left to winter in Ireland, 14 remained on the estuary. In the spring, when WHIT02

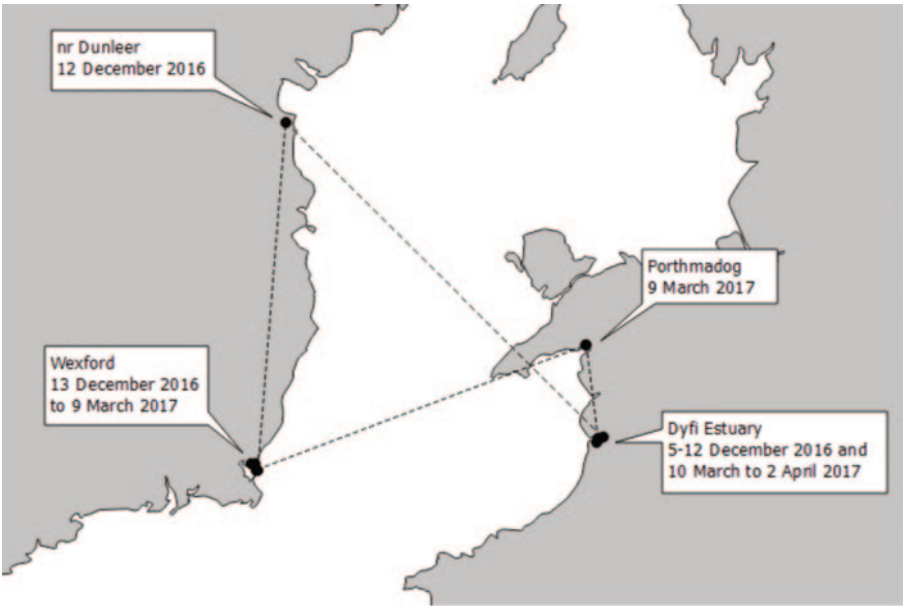

Figure 2. Location and movements of Greenland White-fronted Goose WHIT02 after capture and marking on the Dyfi Estuary, Wales on 4 December 2016 based on GPS tag data. All location data provided by the GPS tags are shown; straight lines were drawn between successive location points and may not represent flight lines.

returned to the Dyfi, the count increased to 22 birds, suggesting a small influx of geese from Wexford.

Spring migration

The two GPS tagged geese left the Dyfi on the evening of 2 April 2017 (see Table 1 for timing of

Event	WHIT01	WHIT02
Last location on Dyfi	02/04/2017 22:00	02/04/2017 18:00
First location in Iceland	03/04/2017 18:01	04/04/2017 00:00
First location at staging area in Iceland	04/04/2017 15:00	06/04/2017 18:00
Last location at staging area in Iceland	03/05/2017 18:00	01/05/2017 00:01
First location in west Greenland	06/05/2017 00:02	06/05/2017 06:00
Last location in west Greenland	19/09/2017 00:01	07/09/2017 00:00
First location at staging area in Iceland	22/09/2017 00:01	08/09/2017 12:01
Last location at staging area in Iceland	28/10/2017 12:00	07/11/2017 17:10
First location in Britain/Ireland	30/10/2017 12:00	11/11/2017 00:02
First location on Dyfi	05/11/2017 00:01	-
First location on Coll	-	11/11/2017 12:00

Table 1. Timing of events in the year-round movements of Greenland White-fronted Geese ringed in Wales in winter 2016/17 based on GPS locations. Depending on the GPS tag schedule, there may be up to 24 hours between successive fixes. All dates and times follow Universal Time Coordinated (UTC).

events). The first location point away from the Dyfi was to the south of Pwllheli at 23h00, suggesting the geese probably left just after 22h00. The close proximity of location data to the north of Anglesey and over Rum (Argyll) at 06h00 on the morning of 3 April suggest that the two tagged geese were flying together and, in all likelihood, all the Dyfi geese flew as a single flock, although one un-ringed bird remained on the Dyfi until 6 April 2017. The flight appeared more or less direct from mid-Wales to Iceland, although with no GPS fixes recorded between west Scotland and southern Iceland it is not possible to say if the geese rested on the sea (Fig. 3). The geese had arrived in south east Iceland

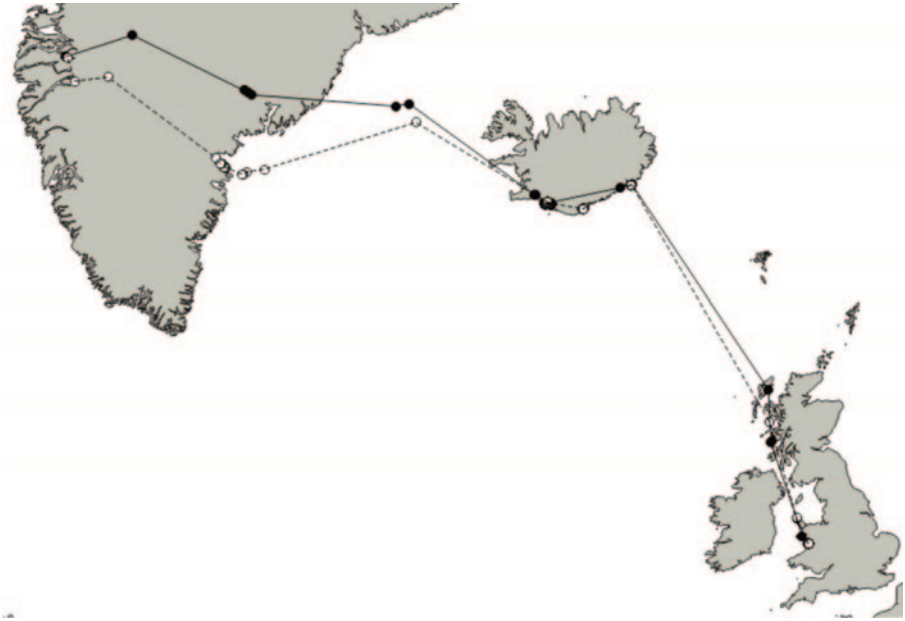

Figure 3. Movements of two GPS tagged Greenland White-fronted Geese, marked on the Dyfi Estuary, Wales, on spring migration in April/May 2017 based on GPS fixes. WHIT01 solid symbol/solid line, WHIT02 open symbol/dashed line. All location data provided by the GPS tags are shown; straight lines were drawn between successive location points and may not represent flight lines.

by 18h00 on 3 April 2017 (Fig. 3), a distance of 1,450km in about 20 hours (an average of c.72 km h-1).

The geese then re-orientated and headed west along the south coast of Iceland. WHIT01 had arrived in the southern lowlands near Hvolsvöllur (63.7°N, 20.2°W) by 15h00 on 4 April, and WHIT02 had arrived there by 18h00 on 6 April. The two geese spent nearly a month approximately 8-10km apart, with the final locations from WHIT01 recorded at 18h00 on 3 May (30 days after arrival in Iceland) and from WHIT02 at 00h00 on 1 May 2017 (28 days), before departing to west Greenland.

WHIT01 had arrived in west Greenland (67.1°N, 50.4°W) by 00h02 on 6 May, taking two days and six hours to cover the journey from Iceland, a distance of 1,380km, and WHIT02 had arrived there by 06h00 on 6 May, five days and six hours after leaving Iceland. WHIT01 arrived at approximately 67.2°N before heading north to 68.2°N on 14 May.

Summer distribution

On 28 May, compared to previous daily movements, the tight clustering of GPS fixes suggested WHIT01 had begun incubating eggs. For the next 27 days the mean distance moved between location points was only ~7m, within the range of error for the GPS tags (see above). The movements of WHIT02 showed a different pattern; it appears to have initiated a clutch and started incubating eggs on 31 May, but by 3 June (four days later) daily movements had increased again, indicating that incubation had ceased. See below for breeding outcomes of the two individuals. The latitude used by both geese for breeding lay at approx. 68.2°N (WHIT01) and 67.8°N (WHIT02).

For approximately 25 days each summer, the geese replace their flight feathers and are rendered flightless (Cramp and Simmons 1977).

Between 28 June and 2 Aug (35 days), the mean distance between successive location points of WHIT02 was 258m (maximum 834m) at approx. 67.8°N, 52.1°W and it is likely that WHIT02 moulted during this period. During the same period, the mean distance between successive location points of WHIT01 was longer at 450m (maximum 2,590m) at approx. 68.2°N, 51.7°W. At this time, both WHIT01 and WHIT02 were located on large lakes or within their perimeters as expected during moult.

Autumn migration

WHIT01 left west Greenland after 00h01 on 19 September, arriving in southern Iceland by 00h01 on 22 September. It spent 35 days near Hvolsvöllur and observational sightings of WHIT01 and her mate indicated that they were accompanied by four goslings (A. Fox pers comm.), confirming a successful breeding attempt. WHIT01 departed Iceland after 12h00 on 28 October and had arrived at Lough Swilly, Eire (54.9°N, 7.6°W) by 12h00 on 30 October. WHIT01 arrived back on the Dyfi by 00h01 on 5 November (Fig. 4). Observations of WHIT01 and her mate on the Dyfi indicated that they were accompanied by two goslings. Thus, two goslings were either lost, or more likely died either in Iceland or on migration between Iceland and Wales.

WHIT02 left west Greenland after 00h00 on 7 September, arriving in southern Iceland by 12h01 on 8 September. It spent 56 days near Hvolsvöllur and sightings of WHIT02 and her mate indicated that they had no associated goslings (A. Fox pers. comm.) thus supporting the suspected failed incubation attempt we referenced earlier. WHIT02 left Iceland after 12h00 on 4 November and flew approximately 110km south east before returning to Iceland. It left Iceland again at some point after 17h10 on 7 November and by 00h02 on 11 November it was recorded off the Sutherland coast; poor battery charge during this period, and thus no GPS fixes, means there is no way of knowing if this bird was in transit over the course of this ~3 day period or if it spent longer in Iceland prior to departing. It arrived on the island of Coll, Argyll, north-west Scotland (56.60N, -6.60W) by 12h00 on 11 November, where it spent the entire winter (Fig. 4).

Discussion

Numbers of Greenland White-fronted Geese on the Dyfi were as low as 36 birds in 1975 but steadily increased during the 1980s and early 1990s (Fig. 1) as the global population increased after the cessation of shooting across much of its range (see Fox et al. 2006 for a review). The decline in numbers on the Dyfi since 1999 may simply reflect changes in the global population, which has similarly declined, and potentially poor annual breeding success of the Dyfi flock. In addition, some of the birds that formerly wintered on the Dyfi may have emigrated to Wexford, Ireland or to parts of Scotland to winter (the reasons for this are unknown). We have demonstrated that some birds pass through the Dyfi in early winter and move to Wexford. It is also likely that the small increase

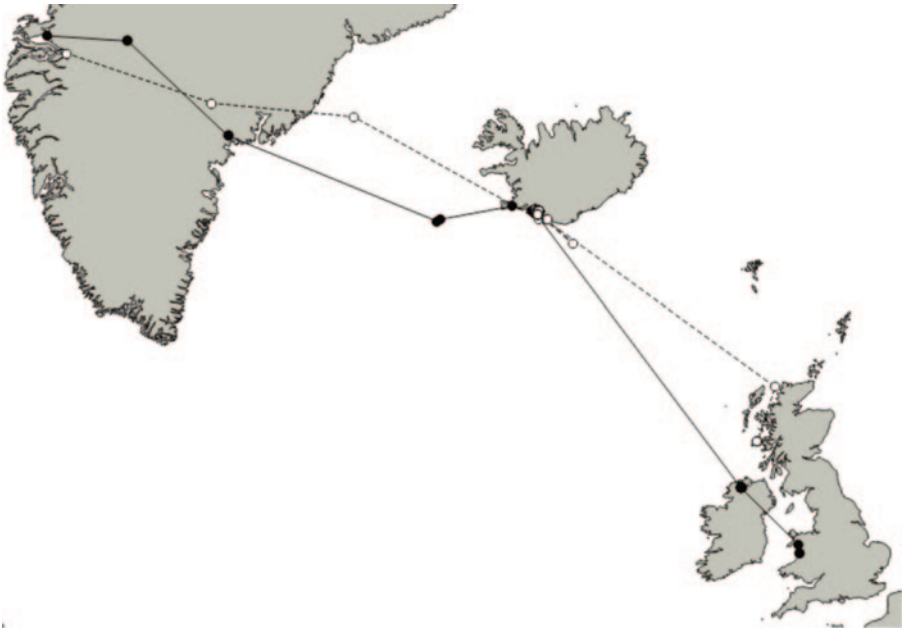

Figure 4. Movements of two GPS tagged Greenland White-fronted Geese, marked on the Dyfi Estuary, Wales, on autumn migration from west Greenland in September to November 2017. WHIT01 solid symbol/solid line, WHIT02 open symbol/dashed line. All location data provided by the GPS tags are shown; straight lines were drawn between successive location points and may not represent flight lines.

in birds on the Dyfi from early March 2017 (including WHIT02 and its mate), and an increase in numbers observed in Anglesey in the same month (from eight to 14 birds), involved birds that had moved from Wexford.

Earlier studies of Greenland White-fronted Geese have suggested very high between- and within-winter site fidelity in the Greenland White-fronted Geese (Wilson et al. 1991, Warren et al. 1992), which would suggest that a voluntary ban, covering the Dyfi for 40 years, will be effective in protecting the flock. However, those studies were based on geese marked at Wexford, Ireland, a site now known to draw geese from elsewhere in winter and where numbers have remained high, despite the fall in overall population size (Weegman et al. 2016). The movements of the birds wintering on the Dyfi were largely unknown (but see below) and this study has shown that the Dyfi wintering flock may contain some transients that use other parts of Wales and move on to winter in Ireland.

The movement of WHIT02 and its mate to Wexford is not unprecedented. In autumn 2001, a Greenland White-fronted Goose, caught in western Iceland and marked with neck collar H0A, was recorded on the Dyfi on 14 November 2001, and was then seen in Wexford on 30 January 2002 (A. Walsh and A. Fox pers. comm.). However, the movement of WHIT02 back to the Dyfi in spring is noteworthy and may suggest that small numbers of birds may have made this movement in recent years, but this would have been difficult to determine through monthly counts alone. WHIT02 arrived on 9 March 2017 in north Wales near Porthmadog at a site where two Greenland White-fronted Geese were recorded on 24 March 2013. Perhaps small numbers have left Wexford in

previous springs using sites in Wales, including the Dyfi and Anglesey, before heading north on spring migration to Iceland. Such connectivity with the Wexford flock (~7,200 birds in 2016/17) gives a little hope that, should the global population increase, re-establishment or bolstering of the mid-Wales wintering flock might be possible. However, the use of other sites in Wales, out-with the Dyfi, by Greenland White-fronted Geese on passage mean that they are vulnerable to being shot by non-members of wildfowling clubs (see below).

Likewise, we had no prior idea where Dyfi geese staged within Iceland, but we do know that geese staging in the southern lowlands are far more exposed to hunting than those in west Iceland, especially those that stage at the Hvanneyri Ramsar site where there is no goose hunting. Many Wexford geese are known to use Hvanneyri, but the Dyfi geese apparently use the southern lowlands, where they will be at great risk of being shot accidentally amongst the large numbers of Greylag Geese (Anser anser) that are hunted legally there (Fox et al. 2002).

The departure date (2 April) from the Dyfi was two weeks earlier than that recorded for eight Greenland White-fronted Geese marked with satellite transmitters fitted at Wexford, which left Ireland between 14 and 19 April in 1998 and 1999 (Fox et al. 2003). However, mean departure dates at Wexford (as elsewhere on the winter quarters) have advanced from 24 April to 28 March between 1969 and 2018 and vary between years depending on prevailing wind conditions (A. Walsh and A. Fox pers. comm.). The area of southern Iceland used by the Dyfi Greenland White-fronted Geese matched that predominantly used by geese that have wintered in Scotland; birds that have wintered in Ireland tend to stage in west Iceland (Fox et al. 1999). The length of stay in Iceland of the two tagged Dyfi geese was longer (mean 25.5 days, range 23-28 days) than that recorded for the birds marked at Wexford (mean 18.2 days, range = 12-21 days, n = 8, 1998 and 1999). However, these differences between recent and more historic data could be due to earlier departures from the winter quarters and prolonged staging in Iceland over the last 30 years (Fox et al. 2014). The mean departure date from Iceland in 1998 and 1999 was 8 May (range 2-10 May) whereas in this study the mean departure date was 2 May.

Observations of WHIT01 in Iceland in spring 2017 suggested that only four of the ten other marked geese that had wintered on the Dyfi were accompanying WHIT01 at this time. Thus, it seems likely that the Greenland White-fronted Geese using the Dyfi are not one single flock, but comprise at least two sub units. WHIT02 and its mate were caught on the Dyfi with WHIT01, but spent mid-winter at Wexford. They re-joined as a single flock in the spring on the Dyfi, migrated to Iceland as a flock but separated immediately thereafter.

The summer quarters of the mid-Wales Greenland White-fronted Geese were largely unknown. A single Greenland White-fronted Geese ringed in Ikamiut (68.63N, 51.85W) west Greenland in July 1946 was shot on Cors Caron, Ceredigion in January 1947 (Salomonsen 1947). The two GPS tagged Greenland White-fronted Geese bred and moulted at approx. 67.8°N and 68.2°N, 100km and 50km to the south of where the Cors Caron bird was ringed in 1946. The geese moult in association with bodies of open water to which they resort when disturbed by Arctic Foxes (Vulpes lagopus). The distances between locations within and between days recorded in July fit well with them moulting on large lakes where they use the lake shores for feeding.

Wales and England are the only countries on the flyway where Greenland White-fronted Geese can be legally shot. On the Dyfi, there has been a voluntary ban on shooting Greenland White-fronted Geese since 1972, and this also now covers all areas controlled by affiliated shooting clubs in Wales. However, from December 2016 to February 2017, during the wildfowling season, the GPS location data of WHIT01 showed that the geese spent over a quarter of the time feeding outwith the area

controlled by the wildfowlers, on fields where the geese could be shot, either deliberately or mistaken for other legal quarry goose species. Small numbers of Greenland White-fronted Geese use other sites in Wales, particularly on passage, where they are also vulnerable to being shot (Green and Mitchell 2018). Twenty-nine White-fronted Geese were reported shot on Anglesey between 1998 and 2010 (Stroud 2011). Outwith Wales, the tagged geese spent 35 and 56 days respectively staging in southern Iceland during the autumn. Here, large numbers of Greylag Geese also aggregate in autumn and can be legally shot, so there is a high potential for mistaken identity especially when considering juvenile birds. Bag statistics from Iceland indicated that between 2007 and 2016, an average of 327 Greenland White-fronted Geese were shot there annually (range 195 to 493, http://px.hagstofa.is/). Despite being protected in Iceland, the geese are mistaken for legal quarry. Although bag reporting in Iceland is mandatory, the reported bag total should be treated as a minimum.

The use of telemetry devices has shone a light onto the year round movements of the Dyfi Greenland White-fronted Geese and provided the first evidence of site use throughout the year, their breeding quarters and how a successfully breeding female was tracked through the year. The study has shown that whilst the population can be considered highly site faithful, individuals within the population have different strategies moving between 'traditional' sites. The telemetry data have highlighted potential areas where the geese may be exposed to hunting and has provided a useful platform for informed conservation decisions about the fate of the population wintering in Wales. With so few birds now wintering in Wales, the chances of capture and deploying more GPS tags are small, however this study has shown the large amount of information that can be derived from a relatively small investment, so future catching attempts should be considered.

The movements of both tagged individuals can be followed in greater detail here: **https://sites.google.com/view/telemetry/gwfg-wales**, although due to sensitivities over land ownership, viewing the location of the geese during the winter months is restricted.

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The distribution of Greenland White-fronted Geese (*Anser albifrons flavirostris*) in Wales 2000-2018 and implications for their conservation.

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Crynodeb

Mae niferodd Gŵydd Dalcen Wen yr Ynys Las ym mhoblogaeth yr hynt a'r rhai sy'n gaeafu yng Nghymru wedi gostwng ers diwedd y 1990au. Yn 2017/18, ymddengys fod dwy haid fechan sy'n gaeafu yng Nghymru yn parhau; un ar aber afon Dyfi ac un yn defnyddio nifer o safleoedd ar Ynys Môn. Mae'n gyfreithlon saethu'r boblogaeth yma yng Nghymru, er bod gwaharddiad saethu gwirfoddol ar dir y mae gan glybiau saethu adar hawliau penodol i saethu arno, yn cynnwys aber afon Dyfi. Dangosodd dadansoddiad o gofnodion o Wydd Dalcen Wen yr Ynys Las ers 2000 fod nifer fychan ar hyd a lled Cymru yn ystod adegau mudo, ond yn enwedig ar hyd arfordir y gogledd a'r de-orllewin. Arhosodd rhai adar am amryw wythnosau, ac ymddengys i rai safleoedd gael eu defnyddio mewn mwy nag un tymor. Dadleuwn fod yr adar sy'n defnyddio Cymru mewn perygl o gael eu saethu mewn ardaloedd nad ydynt dan reolaeth clybiau saethu adar. O ran cadwraeth, mae'r achos dros atal hela yn gyfangwbl i amddiffyn y boblogaeth yn ddiwrthdro.

Summary

The number of Greenland White-fronted Geese in the flyway population and those wintering in Wales have declined since the late 1990s. In 2017/18, two small Welsh wintering flocks apparently persist; one on the Dyfi Estuary and one using a number of sites in Anglesey. The population remains legal quarry in Wales, although subject to a non-statutory voluntary ban of shooting on land over which all wildfowling clubs have specific rights to shoot, including on the Dyfi Estuary. An analysis of submitted records of Greenland White-fronted Geese since 2000 revealed that small numbers of Greenland White-fronted Geese are found on spring and autumn passage throughout Wales, but especially along northern and south-western coasts. Some birds have remained for several weeks and a few sites appear to be have been used in more than one season. We argue that the birds using Wales are vulnerable to being shot in areas not controlled by wildfowling clubs. The legal and conservation case for removing hunting completely to safeguard the population is overwhelming.

Introduction

Of the two sub-species of White-fronted Geese which winter in the UK the Greenland White-fronted Goose (*Anser albifrons flavirostris*) is most associated with Wales. Greenland White-fronted Geese spend the winter in Ireland, and northern and western Scotland, with west Wales being at the southern edge of their range. Numbers in Wales have historically fallen from a probable high of around 1,100 birds in the early 1900s to fewer than 200 by the 1990s (see Fox and Stroud 1985 for

a review) and further to fewer than 40 birds in winter 2017/18. The geographic range of sites used by the geese has also declined, with the Dyfi Estuary, north of Aberystwyth thought to be the only regularly used site since the 1980s. The Dyfi Estuary is designated as a European Union Special Protection Area (SPA) specifically for its Greenland White-fronted Goose population. It is also a Site of Special Scientific Interest (SSSI) a National Nature Reserve and a Ramsar site, and therefore conservation efforts have been particularly concentrated on this site. This paper assesses the distribution of the Greenland White-fronted Goose in Wales since 2000 as well as their use of unprotected staging sites, with implications for their protection.

Methods

Records of Greenland White-fronted Geese were obtained from the British Trust for Ornithology (BTO) BirdTrack database (2000 to March 2018) and from County Bird Reports (2000 to November 2016). The authors (and others) carried out additional survey effort during the annual internationally synchronised counts (in December and March) of the sub-species, organised by the Greenland White-fronted Goose Study.

Results

Current status

Based on documented declines in abundance and distribution during the 1950s-1970s (Ruttledge and Ogilvie 1979), the Greenland White-fronted Goose was protected from winter hunting in Ireland and all White-fronted Geese in Scotland from winter 1982/1983. Because of these co-ordinated conservation measures in the UK and Ireland and coupled with the implementation of cohesive site-safeguard networks, numbers in the flyway population rose from c. 16,600 birds at the time of legal protection, to peak at 35,600 in spring 1999. However, since then, low breeding productivity has caused the population to decline (see Fox et al. 2006). In the springs of 2015 and 2016, the global population of Greenland White-fronted Geese had fallen to 18,854 and 18,879 individuals respectively (Fox et al. 2016, 2017). These totals were below the critical threshold of 20,000 birds set to trigger a review under the International African European Waterbird Agreement (AEWA) (Stroud et al. 2012), of which the UK is a signatory. They are 'red listed' in Birds of Conservation Concern in Wales (Johnstone and Bladwell 2016).

Numbers on the Dyfi Estuary peaked at 400 birds in 1952, but slowly declined to 36 birds in 1975. After a period of recovery, a high of 167 birds was recorded in 1998, but numbers have subsequently declined. In winter 2016/17, 21 Greenland White-fronted Geese were recorded on the Dyfi Estuary, the lowest count since regular counting began in 1959. Number have increased slightly with 26 birds present in winter 2017/18. On Anglesey, a flock of up to 14 birds now appear to winter regularly at a small number of sites including at Malltraeth, but it has proved difficult to locate them and obtain accurate numbers on favoured feeding or roost areas (Green et al. 2017).

Distribution and phenology

Excluding records from the Dyfi Estuary, the Birdtrack database and County Bird Reports provided 227 and 62 records respectively. The distribution of Greenland White-fronted Goose records in Wales, summed by 1km square, for the period 2000 to March 2018 is shown in Figure 1 (n = 62 1km squares, excluding records from the Dyfi Estuary). Where there were repeat observations of the same birds on several dates within a winter, only the maximum number for the duration that they were recorded was used. Figure 2 shows the timing of all records away from the Dyfi Estuary, using maximum counts from sites in each half month for the period 2000 to March 2018.

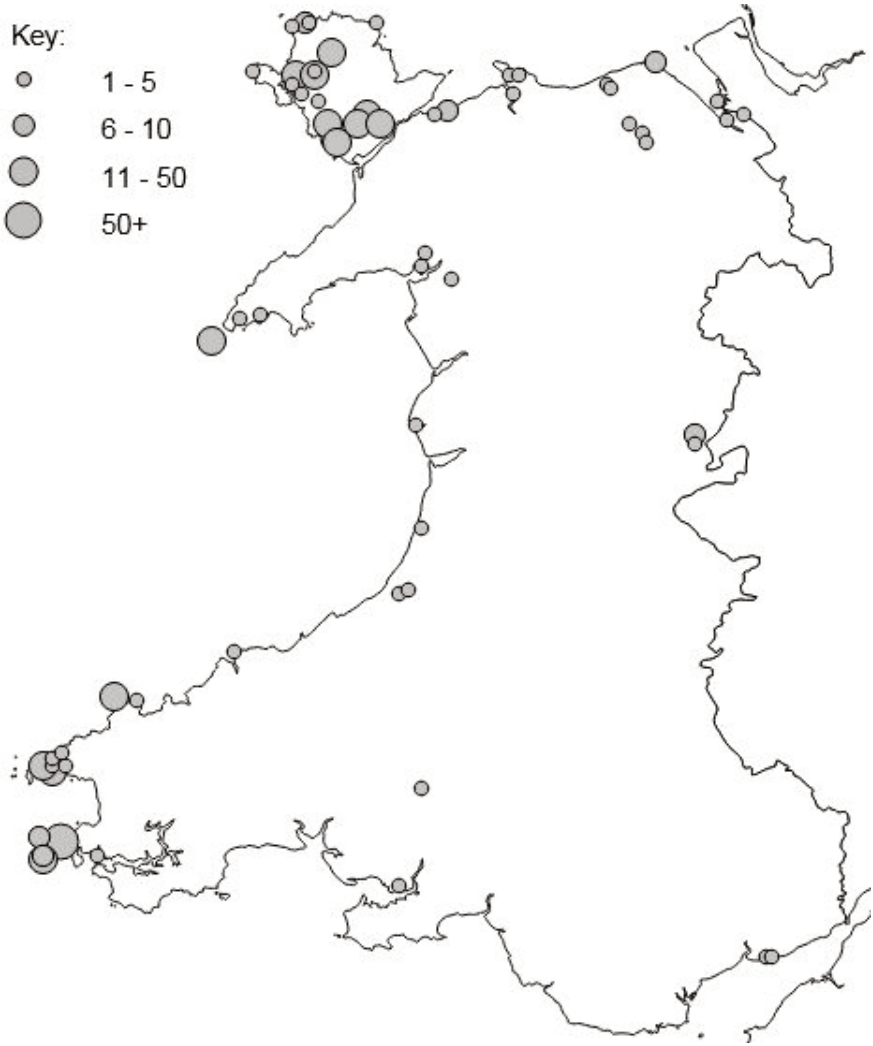

Figure 1. The distribution of Greenland White-fronted Goose records in Wales 2000 - 2018 summed by 1km squares (BTO *Birdtrack* and County Bird Report data). Records from the Dyfi Estuary are not shown. Where there were repeat observations of the same birds on several dates within a winter, only the maximum number for the duration that they were recorded was used.

The Dyfi Estuary, and probably a small number of sites on Anglesey, appear to be the only areas where Greenland White-fronted Geese regularly overwinter in Wales, while other records are principally of birds on spring and autumn passage along northern and south-western coasts, with the geese often staying for only a few days. However, several sites have held Greenland White-fronted Geese for longer periods. Lleweni watermeadows (Denbighshire) held five birds from 11 February to 18 March 2015; Talacre (Flintshire) held nine birds from 18 November 2017 to 14 March

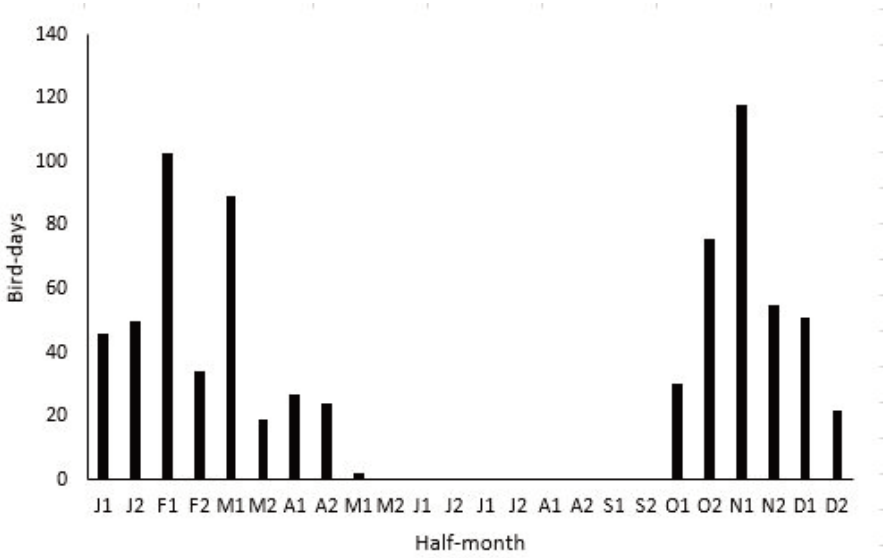

Figure 2. Timing of Greenland White-fronted Goose Records in Wales, 2000 - 2018 (BTO Birdtrack and County Bird Report data), showing maximum count at sites for each half month. Records from the Dyfi Estuary have been excluded.

2018 and Dolydd Hafren (Powys) held three birds from 4 March to 2 April 2010. One area, Marloes Mere (Pembrokeshire) held Greenland White-fronted Geese in eight out of 18 years between 2000 and 2017 with a maximum of 16 birds present between 31 January and 19 April 2010.

Discussion

The Birdtrack and County Bird Report records show a wide distribution of Greenland White-fronted Goose records across Wales, particularly in coastal areas in the north and south-west. Some of these birds may eventually move onto the Dyfi Estuary or Anglesey and form part of the population wintering in Wales, others may stage in Wales before moving on to other wintering areas, such as Wexford in SE Ireland. Recent telemetry studies have shown that some of the Greenland White-fronted Geese caught in winter on the Dyfi Estuary staged both elsewhere in Wales and showed within-winter movements that put these birds at risk of being shot outside of their regularly used sites (Mitchell et al. 2018). Outwith the Dyfi Estuary and Anglesey, a few sites appear to have been used with some regularity, including Marloes Mere (Pembrokeshire), and may have also been used regularly in the past (see Fox and Stroud 1985 for a review). These records reveal that the geese are not confined to the Dyfi Estuary or to sites where wildfowling clubs have the right to shoot during the hunting season when they remain legal quarry.

Even on the Dyfi Estuary, the telemetry study showed that a Greenland White-fronted Goose marked with a Global Positioning System (GPS) telemetry device spent 28% of days during the 2016/17 winter (5 December to 2 April) on farmland outside of the RSPB Ynys-Hir reserve and the areas where the wildfowling club voluntary ban is implemented (Green et al. 2017). The GPS tagged individual was almost always seen with the entire wintering flock on the estuary, so the movements of the tagged bird probably reflected the movements and vulnerability of all the birds on the estuary

during that winter.
White-fronted Geese, including those from Greenland, are legal quarry in England and Wales. There has been a welcome self-imposed voluntary ban on shooting Greenland White-fronted Geese by members of wildfowling clubs on the Dyfi Estuary since 1972 and this was extended to all wildfowling club members in Wales in 2012. However, wildfowlers that are not members of the local clubs, and indeed any shotgun licence holders with permission to shoot over a given piece of land throughout Wales, can legally shoot the geese during the open season (1 September through to 31 January inland and to 20 February on the foreshore).

Between 1998 and 2010, a total of 29 White-fronted Geese were shot on Anglesey (Stroud 2011). Although there have been no bag records received since then, the Welsh Assembly Government has stated that it considers that it is very difficult to know, definitively, if Greenland White-fronted Geese are being shot in Wales (Biodiversity and Nature Conservation Branch of Land, Nature and Forestry Division, in litt. to GWGS, 4 March 2015), especially as there is currently no requirement for statutory bag reporting. With the current decline in both the flyway population and the historically low number wintering in Wales, this is very concerning. There is clear evidence that hunting of Greenland White-fronted Geese on the wintering grounds is additive to normal levels of mortality. Based on studies at Wexford Slobs in Ireland, where the annual hunting kill was accurately known, the difference in population size from one year to the next matched the predicted change based on additive mortality in the population (Fox 2003). In other words, every goose shot was not part of a "huntable surplus" that would have died anyway from other causes, rather their loss was in addition to other sources of mortality and meant at least one less goose the following year, or more if the bird shot was a breeding female. As a result, the population appears extremely sensitive to hunting mortality.

Wales and England remain the only two countries across the bird's entire global range where hunting is legal. This is despite the need to remove all sources of avoidable mortality agreed by the fifth meeting of parties of AEWA under the International Single Species Action Plan for the Conservation of the Greenland White-fronted Goose (Stroud et al. 2012). The plan notes the international consensus "..that hunting cannot currently be undertaken on a sustainable basis and any kill would exacerbate the current unfavourable conservation status of the population..". The Action Plan also stresses the need "..to take all possible steps to eliminate avoidable sources of mortality and disturbance, particularly shooting..". Therefore, the legal and conservation case for removing hunting completely to safeguard the population appears overwhelming.

The welcome non-statutory voluntary ban on shooting by wildfowl club members has made a major contribution to the protection of Greenland White-fronted Geese in Wales. However, it fails to address the principle of increasing overall survival in the population by removing hunting mortality within a legal framework. The Welsh population continues to be legal quarry and total protection from hunting is therefore essential across Wales.

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The status of the Ring Ouzel (*Turdus torquatus*) on the Aran mountains

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Crynodeb

Mae'r papur yma yn rhoi canlyniadau arolwg o Fwyalchen y Mynydd yn nythu ym mynyddoedd yr Aran ym Meirionnydd yn 2014. Cafwyd hyd i bedwar ar ddeg o diriogaethau, gyda nythu wedi ei gadarnhau mewn pump ac yn debygol mewn naw. Roedd nifer o diriogaethau yng Nghwm Cywarch, ar ochr ddwyreiniol Glasgwm, lle'r oedd pedwar pâr ar hyd 1,500m o darren.

Summary

This paper reports on a survey of breeding Ring Ouzels in the Aran mountains in Meirionnydd in 2014. Fourteen territories were located, with breeding confirmed at five and probable at nine. There was a concentration of territories in Cwm Cywarch, on the eastern flanks of Glasgwm, where four pairs were located along 1,500m of escarpment.

Introduction

The Aran mountains have long been considered a stronghold for breeding Ring Ouzel (*Turdus torquatus*) in Meirionnydd (Lovegrove et al. 1994). Little published data exists for the entire range however, other than the limited datasets collated during the National Breeding Atlas survey initiatives. UK wide surveys for Ring Ouzel have focused on a very small area of these mountains and a survey covering the whole of this upland block, utilising the best methodology available for this species, has not been conducted previously. This short paper summarises the findings of a survey conducted for Ring Ouzel across the Aran range in 2014, enhancing and updating our knowledge of the species in this area, providing a baseline for future repeat surveys of this key upland species.

Methods

The survey covered all apparently suitable habitat from Moel Ddu at the northern limit of the main Aran ridge, to the Waun Oer and Maesglase hills in the south. Survey boundaries were delineated by the forestry plantation edges on the flanks of the range in the south and west and the minor road running through the Llanymawddwy and Cwm Cynllwyd valleys to the east.

A tape-lure was used to mount searches, enabling extensive areas to be covered efficiently and relatively quickly in suitable weather conditions. The survey period extended from mid-April to late June. Breeding status at each occupied territory (possible; probable; confirmed) was assessed according to the criteria as described in the standard survey methodology for the species (Gilbert et al. 1998).

Results

Fourteen territories were located, with breeding confirmed at five and probable at nine. A notable concentration of territories was recorded in Cwm Cywarch, on the eastern flanks of Glasgwm, where four pairs were located along 1,500m of escarpment. Elsewhere, two territories were recorded on Aran Benllyn along approximately 1,000m of cliff face, other territories being well distributed across the range, with a mean nearest neighbour distance of 1,716m (range 355-3,350m).

The altitude of the occupied territories ranged widely from 350 to 750m, average altitude being 533m. Ten of the territories were located between 400 and 600m, three lying above 700m and only one under 400m. Most of the territories held easterly aspects, this being dictated by the topographical character and typically east facing cliffs and crags of the range, with one site facing due west, one north and one south.

The majority of the territories were strongly associated with steep escarpments, cliff and crags where heather cover was of sufficient extent, height and density to allow nest concealment. Two territories were associated with steep broken ground with little or no heather cover, where sheep grazing had suppressed vegetation growth and nest concealment strategy may be reliant on small crevices or ledges on rock faces potentially offering some ground cover or protection. One pair was located in a small disused slate quarry, another pair holding territory in a narrow, steep river gully on grassy sheepwalk, where a mosaic of gorse and limited heather cover provided suitable nesting habitat (Note: a pair of Ring Ouzels was recorded holding territory in another steep, mainly gorse-lined stream gully in the east of the survey area by this observer in 2007).

Three nest sites were noted. One of these was located on the side of a small gully in deep heather on a large, broken cliff complex, another on a small heather-clad ledge at the base of the same escarpment, approximately 2.5m off the ground. The third was on an inaccessible recessed ledge, with heather growth, on the open face of a small crag.

Discussion

Breeding Ring Ouzels are well distributed across the Aran mountain range. The breeding concentration recorded on the heather-clad cliffs of Cwm Cywarch, on Glasgwm, is notable, suggesting this area may provide optimal nesting habitat for this species with its vast expanse of steep rock faces, gullies, scree, luxuriant heather and Bilberry (*Vaccinium myrtillus*) cover, Bracken (*Pteridium aquilinum*) stands and occasional small pockets of scrub. The adjacent mosaic of grassland (unimproved, agriculturally semi-improved and improved), dry heath, wet flush and blanket bog habitats potentially provide favourable foraging opportunities for all stages of the breeding cycle.

The cliff complex of Cwm Cywarch is also notable in that its vegetation characteristics are not typical of much of the Aran range, which tends to be dominated by sheep-grazed acid grassland habitat on slopes and ridge tops, with blanket bog on plateaux areas. The steep east faces of Aran Fawddwy and Aran Benllyn hold a similar topography of exposed rock faces, gullies and scree, though vegetation character is noticeably different on these faces, with heather extent, height and density much reduced through greater rates and impacts of sheep grazing, reducing vegetation diversity and growth. This is surely a key factor influencing the lower densities of breeding Ring Ouzels recorded on these extensive cliffs in comparison to Cwm Cywarch. This survey has demonstrated that Ring Ouzels can select cliff habitat largely devoid of heather and Bilberry cover for nesting,

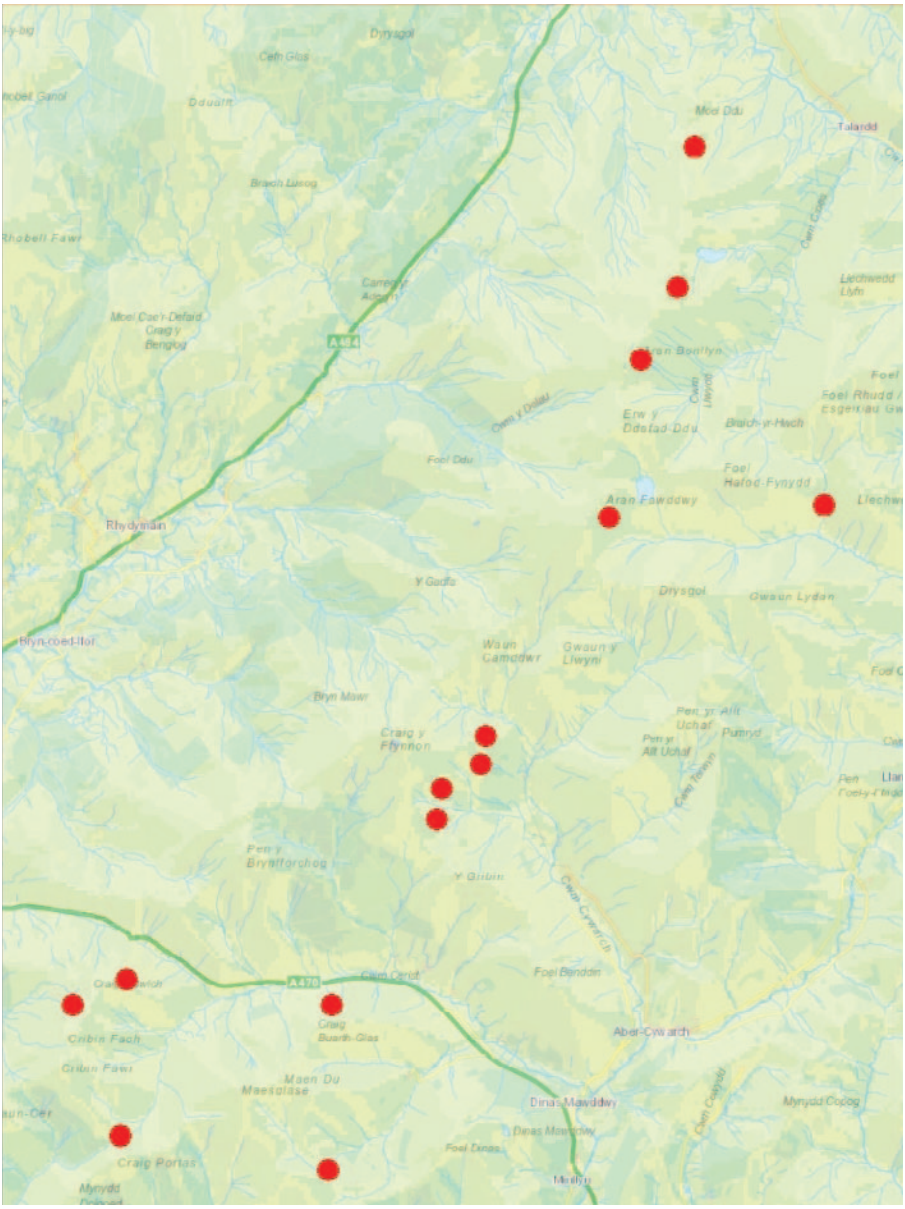

Figure 1. Occupied Ring Ouzel territories in the Aran mountains 2014.

though it would appear logical that the habitat condition is less favourable for breeding on such escarpment type and breeding density will be lower than on similar topography where heather growth is abundant, mature and dense.

The lower median altitude of the Cwm Cywarch cliffs (500m) compared to the higher expanse of the Fawddwy and Benllyn faces (750m) should also be considered when assessing factors influencing breeding distribution on this range. Recent study on nearby Cadair Idris does suggest that such altitudinal range should not limit Ring Ouzel breeding range in this region of Wales, with over two-thirds of the 25 territories recorded on that mountain in 2008 lying above 600m (Smith 2011).

It would seem reasonable to conclude that the Aran mountains could potentially hold greater numbers of breeding Ring Ouzels and that their distribution and status on the mountain may be limited currently by habitat condition, where both historic and current sheep grazing levels have removed and suppressed heather growth across large areas of the massif.

References

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